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EPSILON GUNBOATS FOR CHINA.

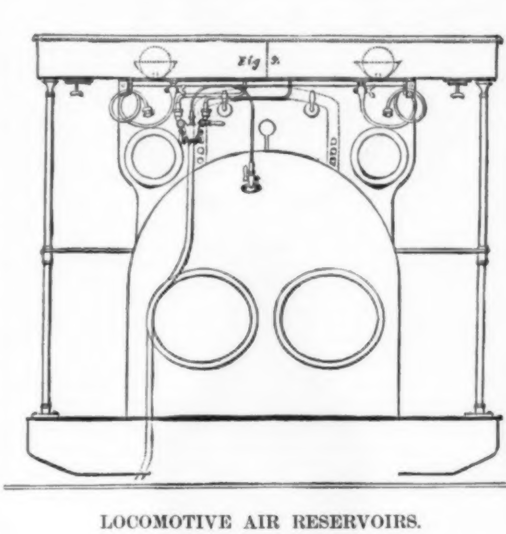
THE Chinese Government, feeling the necessity of providing for its coast defenses when its neighbor Japan (having secured the services of Mr. E. J. Reed, C.B., M.P.) was constructing an ironclad fleet, was advised by Mr. Robert Hart, the Inspector-General of Chinese Imperial Maritime Customs, to order a few small steamboats carrying heavy guns. Mr. Hart was, therefore, instructed to invite proposals from Sir W. Armstrong & Co., of Elswick, Newcastle-on-Tyne, a member of which firm (Mr. Rendel) had introduced the "Staunch" type of gunboats. In the result, he intrusted to that firm the entire responsibility of producing four gunboats, representing a high development of the original type. Hence, the now well-known Alpha and Gamma types of gunboats, the latter of which we illustrated and described in our journal of March 10, 1877.

We now give an illustration of the Epsilon series, which are a further advance on the original type. Four vessels constitute this new series, and are identical in every respect. They measure 127 ft. in length, 29 ft. in beam, their draught is 9 ft. 6 in., and their displacement 440 tons. On their official trials they realized a mean speed of over ten knots (eleven and a half miles), with 430 indicated horse power. They make nine knots going backward, and, having bow rudders and suitable lines, can be equally well handled whether running ahead or astern. These vessels are wholly of steel; they have twin screws, and separate engines and boilers, and tripod-masts. The engines and boilers, the magazines and shell room, are all protected by being under the water line. For further security the hull is divided by four transverse bulkheads and a longitudinal bulkhead forward of the engines, there being also a horizontal under-water deck over the magazines. The coal bunkers contain seventy tons, and the actual consumption at full speed is six cwt. per hour.

The main feature of the vessel is the great gun, which is placed on line with the keel, in the bow, and is mounted and worked wholly by hydraulic machinery. This enables five men to manage it efficiently, and at the same time gets rid of all complicated mechanism. There are no chains, wheels, cogs, or gearing—not even a gun carriage. The gun lies on the deck between two great beams with two pistons sliding upon them, which take hold of the trunnions, and there is nothing more to be seen.

In the Epsilon series the great gun weighs thirty-five tons, whereas in the Gamma series the gun weighed thirty eight tons. Nevertheless, owing to the recent extraordinary advance realized by the Elswick firm in the power of ordnance relatively to its weight, the new 35-ton gun is much more powerful than the old 38-ton gun. With the 235-lb. battering charge, the 35-ton gun has nearly one-fifth more penetrative power than the 38-ton gun with its battering charge—the actual figures being 356 foot-tons per inch of shot's circumference as compared with 300. With a charge of 250 lb. the 35-ton gun has given its projectile a velocity of 1,925 ft., equal to 400 foot-tons energy per inch of circumference. The high initial velocity of the 35-ton gun causes the trajectory of its projectile to be very flat, and thus gives the gun a much better chance of hitting any object, while also largely increasing the range of the gun. Thus, the Chinese Government now possess the most powerful guns afloat.

In addition to their big gun, the new gunboats carry field guns and Gatlings to keep off small enemies.—*Illustrated London News.*

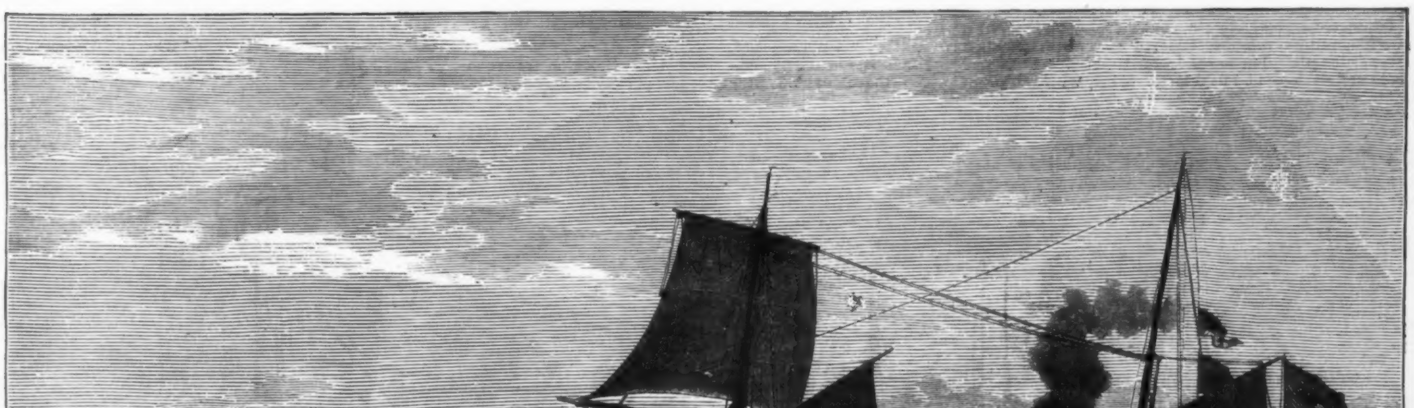


LOCOMOTIVE AIR RESERVOIRS.

LOCOMOTIVE AIR RESERVOIRS.

ON some of the freight locomotives of the Paris, Lyons and Mediterranean Railway a novel feature is the respiratory apparatus (Galibert's system). On the section of the line from Alais to Bastide these engines have to traverse some narrow and badly ventilated tunnels, and notably one at Albespeyre, the air in these tunnels becoming so vitiated by the passage of the trains as to sometimes seriously affect the drivers and stokers. To avoid this the apparatus just mentioned has been introduced, it consisting of an air reservoir fitted with tubes through which the men can breathe while a tunnel is being traversed. The air reservoir forms the roof of the driver's cab, and it is divided into two compartments, these compartments—which have a capacity of 8·8 cubic feet each—being for the use of the driver and stoker respectively. Each compartment is fitted with a long India-rubber tube furnished at the free end with an ebonite mouthpiece, which is applied to the mouth of the user while the tunnel is being traversed, respiration through the nose being at the same time stopped by the application of a spring pincher which closes the nostrils. To prevent the fatigue of the respiratory organs which would be caused by a variation of the atmospheric pressure within the reservoir, each compartment is fitted with an India-rubber bag, the interior of which communicates with the outer air; this bag by expanding or contracting maintains the pressure within the reservoir the same as outside. The renewal of the air in the reservoir is effected, when the engine is out of the tunnel, by means of a small Giffard exhauster. As the air is exhausted by this apparatus fresh air enters by an inlet valve with which each compartment is provided, this valve being closed by hand when the engine enters a tunnel.—*Engineering.*

THE old Superior rail mill of Pittsburgh, which had been idle for several years, is rolling 6,000 tons of steel rails for the Denver and Rio Grande Railroad.



NEW GUNBOATS BUILT IN ENGLAND FOR THE CHINESE GOVERNMENT.

DIVING BELL USED IN THE CONSTRUCTION OF THE SECOND DRY DOCK IN POLA.

THE application of diving shafts instead of bells is by no means a modern innovation. As early as 1778 Mons. Coulomb had one constructed for removing the rocks in the Seine at Quilleboeuf, and we believe that this was the first time that a continuous current of air was maintained by means of bellows. The barge employed for carrying the shaft was about 8 meters long, 3 meters in the beam, and 3 meters deep. The shaft, which was fixed in the center of the barge, was 4 meters long, and had an area of 3 square meters. The manner of working was as follows: As soon as the tide began to ebb the shaft was placed over the desired spot, so that before low water it rested on the bed of the river; the workmen entered at the top through a manhole, and as soon as the latter was closed, air was pumped in to expel the water. A similar apparatus, but of a decidedly better construction, was employed in 183) in removing about 2,200 cubic meters of rock in the entrance to the harbor of Croisic in the department of the Loire Inférieure. The barge in this case was of iron, 8·75 meters long, 3·85 meters wide, and 2·45 meters deep, with semicircular ends, the shaft being placed in the middle. The dimensions of the latter were 3·45 meters in height, with a cross section of 3·5 meters by 2·9 meters, at a depth of 1·3 meters from the deck of the barge. A horizontal grid was placed for the workmen to rest on while the water was expelled or allowed to return. The shaft was sunk by means of water ballast, and the air forced in by an air pump driven by steam power on deck.

A diving shaft with air valves was employed in 1850 in the construction of the large dam on the Nile. The vessel in this case was 33 meters long and 10 meters wide. The shaft, which could be let down about 5 meters below the keel, had a sectional area of 40 square meters, and permitted the employment of 40 workmen at a time in setting the masonry under water.

The apparatus, at present in use in connection with the blasting operations on the Rhine, is very simply constructed. The barges are of timber, 28 meters long, and 5·7 meters wide on deck, with a central square opening 3·5 meters on the side, through which the shafts are lowered. The latter are of iron, cylindrical in form, with a diameter of 3·2 meters and a depth of 6·6 meters. Admittance is gained by two air sluices to each shaft, and the air pumps are worked by the same engines which raise and lower the shafts. An apparatus somewhat similar to the one in question was employed at the removal of Hell Gate, New York. The latter apparatus consisted of an iron bell, 9 meters in diameter, at the end of a telescopic tube, 3·6 meters wide, attached to a vessel at anchor. This, however, was not kept free from water by compressed air; therefore, strictly speaking, it was not what is generally understood by a diving shaft.

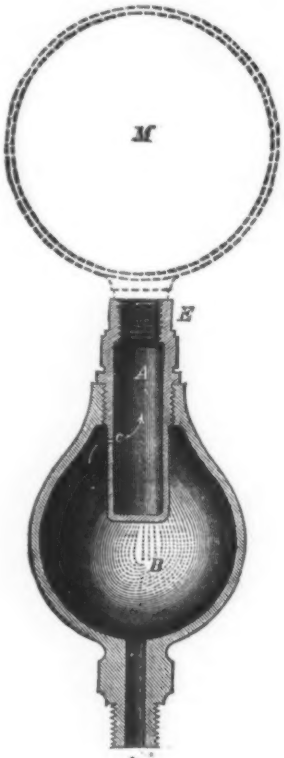
As will be seen from the accompanying figure, the apparatus used at Pola differs in many particulars from any previously constructed. The shaft, instead of being placed in the middle of the barge, is situated at the end, so that it can be lowered so to work at the foot of walls, coffer dams, etc., without any difficulty. It was employed for removing the mud from the surface of the rock on which the dock is built, for clearing away the weathered stone, filling up crevices, and planing the surface for the foundations. Owing to the extra leverage produced by the buoyancy of the compressed air with the shaft at the end of the barge, a considerable amount of water ballast was necessary to counteract its influence. The position of the ballast tanks is shown by the letter A. The shaft itself is similar in construction to those used in caissons for pneumatic foundations. It is closed at the upper end by air sluices, is telescopic in form, and can be lowered to any depth from 4 to 12 meters. The bell attached to the lowest end of the shaft is 3 meters wide, 6 meters long, and 3·7 meters high.

The tubes are respectively 1·0 meter, 1·4 meters and 1·6 meters wide, and are raised or lowered by a chain attached to the lower length. The barge is of timber, 26·10 meters long, 5 20 meters deep, and 9·50 meters wide, with a draught of 2·10 meters. During the period of construction the apparatus was in almost constant work for 560 days and nights, and the amount of material raised and lowered was 3,000 cubic meters of mud of variable consistency, 2,900 cubic meters of broken rock, and 400 cubic meters of cement for filling up and planing the surface. During the heat of summer, the air pipe was jacketed with a tube filled with fresh sea water, and by this means the temperature in the air sluices was kept down to 89° Fahr., and that in the bell to 82½° Fahr. The work, as well as the apparatus, were constructed under the superintendence of Herr V. Heider and Herr A. Lenk, to whom we are indebted for the above data.

A, reservoirs for water ballast, B, steam crane for raising the diving bell; C, transmission for raising and lowering materials; D, capstan for altering position of barge; E, boiler; F, steam engine for compressing the air; G, steam engine for raising materials and working the capstan; H, cabin; I, workmen's room.—*Universal Engineer.*

IMPROVEMENT IN STEAM AND AIR GAUGES.

THE annexed cut illustrates a new device for the protection of steam and air gauges, which is the invention of Mr. F. zur Nedden, in Hanover, Germany.



IMPROVEMENT IN STEAM AND AIR GUAGES.

It consists of the two chambers, A and B, which are so connected that A extends into B. The part D is screwed into the boiler, and the gauge, M, is fastened at E. The communication between A and B is through a very small opening, C. If the pressure in the boiler increases very suddenly, the steam will pass into B with great force, and if A were not interposed would strike the gauge, M, with this force, and probably damage the same considerably. Now, however, the steam is detained by A, and must gradually pass through C into A, and thus its rapidity decreases and it cannot damage the gauge. This device also prevents impurities from being driven into the gauge by the action of the steam. As gauges are very expensive and very difficult to repair, this simple device will be found to be of great advantage.—*Chemiker Zeitung.*

SHOE PEGS AND PEGGING MACHINES.*

Peg A wooden nail or pin.

1 (*Shoemaking.*) A small pin of wood (maple) for securing the *upper* and *counter* to the *sole* of a boot or shoe; and for securing the extra *sole* to the upper one, or the *lifts* of the *heal-tap* to each other in *builling-up* the heel.

Copper wire pins have been substituted; also small pins of leather; also screw pegs.

The term gives rise to many compound words—pegging awl, peg-making machine, peg-driver, peg-float, peg-cutter, etc.

Fig. 1 shows a number of different kinds:

a has pegs glued to paper, so as to admit of being fed in a ribbon.

b shows a plain and a notched peg, which is designed to be saturated with shoemaker's wax.

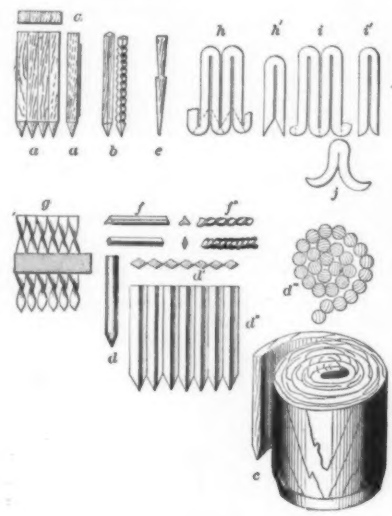


FIG. 1.—SHOE PEGS.

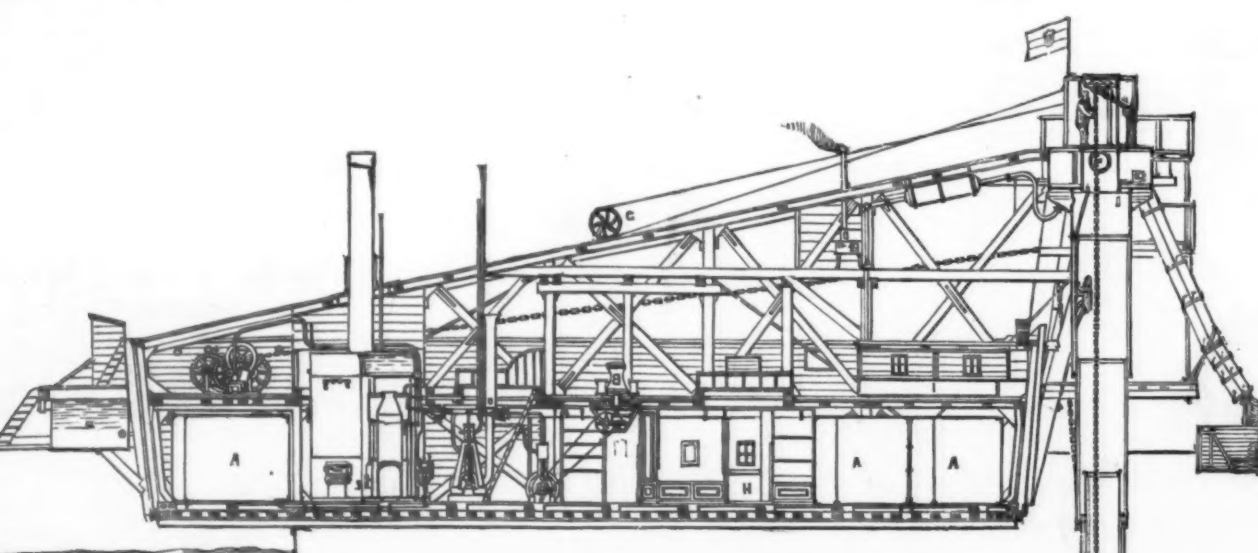
c is a peg-strip in which a ribbon of wood is cut out with one sharp edge, the pegs being separated therefrom in the pegging-machine by a chisel and driven by a blow.

d d' d'' d''' are pegs of condensed leather, neatly separated but adhering sufficiently to be fed as a strip.

e is a barbed peg.

f f are pegs made of wires of various angles and twisted.

* From "Knight's Mechanical Dictionary." Houghton & Osgood, 21 Astor Place, New York.



DIVING BELL AS USED AT THE POLA DOCK.

g shows a row of cable screw pegs soldered on to a metallic ribbon for feeding in a pegging-machine.

h h′ are modes of making staple pegs for boots and shoes by folding the wire and cutting out one bight, leaving the staple with two sharp points, which spread apart like *j* in driving into the shoe sole.

i i′ show another mode of making the staple-peg.

j illustrates the position assumed by the branches when driven by a blow from above.

2. (*Music.*) A turn-pin on which a string of a musical instrument is stretched.

Peg-cutter. An instrument or machine for removing the ends of pegs from the insides of boots and shoes. A *float.* In the example this is pivoted in the stock and has a flange

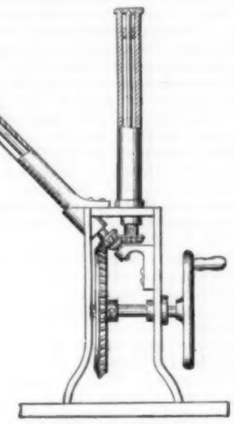


FIG. 2.—FLOAT. FIG. 3.—PEG-CUTTING MACHINE.

beneath, in one of whose notches the spring dog is engaged to maintain the *float* in the required angular position. The stock stands in a hole in a bench.

In Fig 3 the cutters at the ends of the shaft have a rotary motion, imparted by gearing and a hand-crank.

Peg-float. An implement for rasping pegs from boots and shoes. In the example, the cutter, instead of being worked directly by hand, is reciprocated by a crank-wheel, connecting-rod, and elbow-lever.

Pegging-awl (*Shoemaking.*) A stiff awl with a four-sided

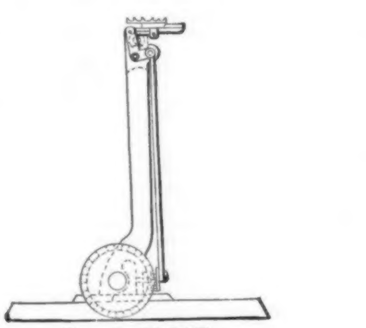


FIG. 4.—FLOAT.

blade, approximating the shape of the peg which is to occupy the hole. It is driven by a hammer.

Pegging-jack. An implement for holding a boot or shoe, and varying its position while being pegged.

In the example, the latter object is effected by varying the position of the curved arm on the standard, A, by means of cams with handles, B F. The adjustable pad, H, supports the forepart of the last, while the heel may be tipped by means of the threaded rod, K.

Pegging-machine. An apparatus for driving the pegs which unite the soles and uppers of boots and shoes. The pegs are usually cut from what is called a peg-strip, which is a

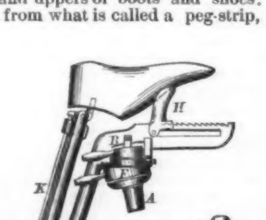


FIG. 5.—PEGGING-JACK.

ribbon of wood, the grain running across the width of the strip, and fed to the parts which cut off a peg and then drive it.

In the illustration, the long jack standard is hinged by a universal joint in the foot-lever, which is weighted at one end to hold the shoe in contact with the pegging and feeding devices, and at the other with a stirrup or foot-rest to disengage the finished shoe. The jack is capable of lateral and longitudinal motions upon the standard, to present the surface of the sole at the point of contact with the pegging devices in a horizontal plane. The vertical plunger, carrying an awl and a driver, is operated by a cam and gearing. The rotary feed is immediately back of the peg-guide, and operated by a pawl and ratchet receiving motion from the main gearing in any suitable manner, ordinarily by a cam. The peg-strip is fed into the guide from a coil of practically indefinite length and from which a peg is cut at each fall of the driver, by a lateral knife, immediately before being driven into the shoe. The long jack-standard brings the mechanism near the eye of the workman.

The two requisite conditions are that the point of contact of the shoe-sole with the pegging-devices must be the center

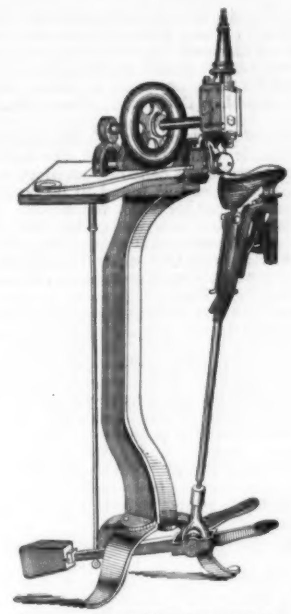


FIG. 6.—PEGGING-MACHINE.

of motion of the work for the time being; and secondly, the surface of the sole at the point of contact with the pegging machine must be kept in a horizontal plane.

In Goddu's (Fig. 7), the awl, *e*, and peg-driver, *d*, are simultaneously operated by a spring actuating the plunger, F, to which they are both attached. The strip of pegs,

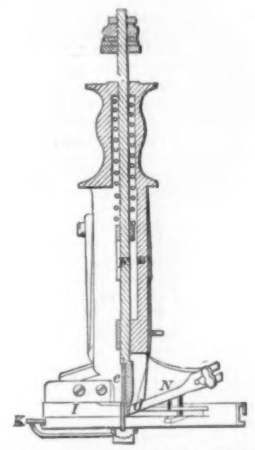


FIG. 7.—PEGGING-MACHINE.

placed in a feed-trough, I, is advanced by a follower, K, and each peg is separated by a flexible knife, N, which also holds it in position for being driven.

The device, Fig. 8, is for cutting off the projecting ends of pegs within the shoe during the process of pegging. The shoe-supporting horn, *c*, has a slot, *d*, in which works a knife, *e*, operated by a combination of levers, *o p*, the upper member of which has a projecting pin working in a slotted cam-shaft.

Sargent's machine is particularly designed for shoes, of which the uppers and soles are united by screw-threaded

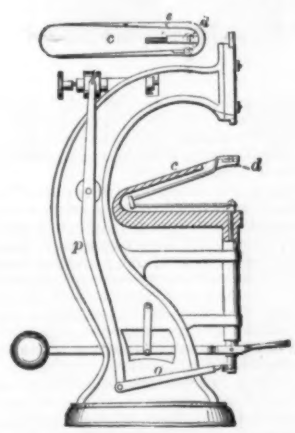


FIG 8.—PEG-CUTTING MACHINE

wire cut to proper length during the operation of pegging. This is effected by a circular cutter connected with a rock-shaft. As the nails are cut off they descend through a peg tube, assuming a vertical position, and are driven home by a plunger actuated by a spring, *a*, and retracted by a pin on the wheel, *b*, engaging a shoulder on the plunger.

The shoe is advanced the proper distance to drive each nail, by a swing-plate, *c*, whose foot is alternately lifted in and out of contact therewith, and is held at the moment of driving by the foot of the peg tube.

The shoe is fixed on a jack mechanism consisting of: (1) a supporting upright, *d*, pivoted to the end of a weighted lever, and is so swiveled as to admit of movement both laterally and vertically; (2) jack-holder, *e*, joined to the upright by a pin, *f*, its vibratory movement on the upright being restrained by stops so as to limit the tipping of the last. A spindle, *g*, projects from the holder on which the jack is mounted, and is supported on a socket piece, allowing free rotary movement of the jack on the spindle; (3) a last-holder, *h*, supported directly over the spindle by a screw, and having a curved arm, *i*, to which the arm, *k*, carrying the heel

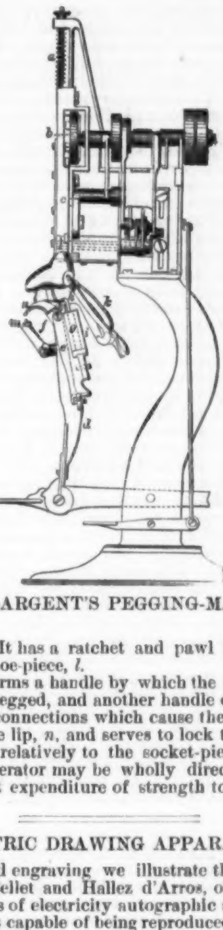


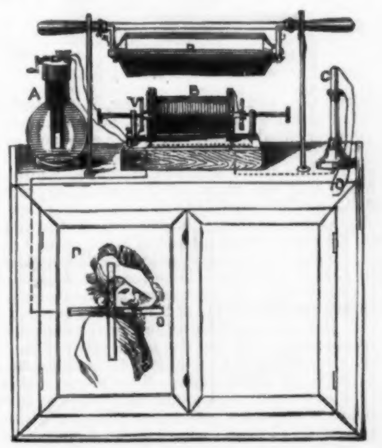
FIG. 9.—SARGENT'S PEGGING-MACHINE.

pin is jointed. It has a ratchet and pawl for forcing the last against the toe-piece, *l*.

The arm, *i*, forms a handle by which the operator guides the shoe being pegged, and another handle operated by the other hand has connections which cause the pin, *m*, to engage a slot in the lip, *n*, and serves to lock the shoe in stationary position relatively to the socket-piece, so that the efforts of the operator may be wholly directed to guiding the shoe without expenditure of strength to keep it in position.

ELECTRIC DRAWING APPARATUS.

IN the annexed engraving we illustrate the apparatus devised by MM. Bellet and Hallez d'Arros, of Paris, for obtaining by means of electricity autographic stencils of writings and designs capable of being reproduced by lithography or upon metals by the acid-graving processes. A small Ruhmkorff coil, arranged in the following manner, is employed. A metal plate is united to one of the poles by means of a wire, and the other pole is connected to the core of an ordinary blacklead pencil or suitable point by means of a very fine wire. On the metal plate is fastened by means of gum a thin sheet of paper previously dipped in water containing sea salt. The induction coil is then set in action, and the design it is required to reproduce is drawn on the paper attached to the metal plate with the pencil (or point), by which means the two poles are brought together, and the electric sparks dart continuously from the point of the pencil or point, and produce on the thin paper small holes corresponding with the lines of the design. The metal plate should be placed on some insulating substance. The design or writing thus finished, the metal plate is dipped in water and the paper carefully removed. The stenciling thus obtained, it is easy to transfer it to stone by inking a sheet of paper with transfer ink, and then placing the stencil thereon and covering it with a sheet of white paper and pressing it sufficiently for the ink to pass through the holes in the stencil. A proof is thus obtained which can be transferred in the ordinary way. The transfer can also be made on zinc, by which a typographical stereotype may be obtained. In order



to obtain an engraving or etching on metal it is necessary to proceed as follows:

A well polished copperplate is covered with a thin layer of varnish. On this varnish a sheet of thin paper or suitable material is pressed, and upon executing the writing or design thereon with the electric pencil (or point) the electric spark will penetrate the paper and varnish at the same time and leave the metal bare at all parts touched by the pencil or point. The plate is then dipped in a nitric acid bath of 20 deg.; the acid will attack the metal where not covered with varnish, and after two or three minutes' immersion an

engraved plate is obtained from which a great number of copies can be produced, "exactly similar to etchings obtained by engraving on metal."

The engraving shows the apparatus complete, in elevation: an inclined table or desk with a horizontal portion at back upon which the coil and the battery stand. A represents a Grenet bichromate battery; the zinc is fixed at the end of a toothed rack worked by a pinion and small handle to make or break contact with the liquid. B is a Ruhmkorff coil showing the end of the central core of soft iron facing the battery; V is a ring fixed at the end of the coil, and carrying a metal plate replacing the ordinary trembler. At the other end of the coil is an arrangement for preventing the operator from receiving shocks; it consists of a small piece of brass fixed in the center of a disk of ebonite, and connected to the coil by the wire shown. By this means an induced current is set up, by which is obtained a secondary spark, between the point of the regulating screw and the piece of brass. This secondary spark prevents any kind of shock in the apparatus, and allows the pencil to be brought into contact with the metal plate without causing electric sparks; it is only when the point of the pencil is in direct contact with the paper fastened to the plate that the spark is produced, and at the time the sparks cease between the point of the screw and the small button of metal. This arrangement allows drawing or writing to be represented on the paper by a number of small strokes thereon; the paper will be found to be perforated when it is taken off the metal plate. The pencil, C (shown in its holder), is prepared by cutting an ordinary point at one end, and paring away the wood at the other, so as to leave a portion of the lead exposed. A small cap or clamp of ebonite containing a metallic brush for making contact with the blacklead of the pencil is then fitted firmly on the end. D is an insulated copper plate, and O a cross (seen in dotted lines, forming a spring, and carrying the metal plate for making the electric contact). When the drawing is finished (if the paper has been gummed) the plate must be dipped in water and the sheet of paper taken carefully off; the flaps of the desk are then opened, in one side of which is a plate of zinc for inking, and in the other a piece of thin transparent silk is stretched on a movable frame; on this fabric is placed the stencil obtained by means of the pencil; the fabric is then inked by means of a roller, after which a sheet of paper is placed beneath the frame, and pressure is exerted thereon by means of the roller, R. The sheet of paper with the impression thereon is removed and replaced by another, and so on. The impressions can be produced also in the following manner, but in this case the desk will not have two flaps opening laterally, but one door and one compartment: On a dabber covered with cloth (previously inked by means of a roller or brush) is placed a fabric of fine thin transparent silk on a frame on which the stencil has been placed, and on the top of the stencil a sheet of paper; pressure is exerted by means of the roller, R. The ink penetrates the silk and comes through the holes of the stencil, which is reproduced on the sheet of paper. The rollers, for the time being, are placed on two forked supports. On that part of the desk opposite to the metal plate is placed a blotting pad.

NEW KALEIDOSCOPE.

Some improvements in kaleidoscopes, having reference mainly to the adaptation of their principle of construction to more useful purposes, have been invented by Mr. McIlvenna, of Liverpool. The invention consists in dispensing with the tube altogether, and placing two vertical mirrors or several pairs of vertical mirrors meeting at or close to a line at an angle of 60 degrees; on this line, beneath the mirrors, a pivot is placed on which a horizontal disk or series of disks hang free to revolve; on these the patterns, pictures, etc., are placed. To make the apparatus more perfect the mirrors can have their lower edges rounded and beveled to an edge at the mirror side; by this means the lines formed in the image by the thickness of the glass are not so apparent.

Fig. 1 is a side view partly in section; Fig. 2 a plan; and Fig. 3 a back view.

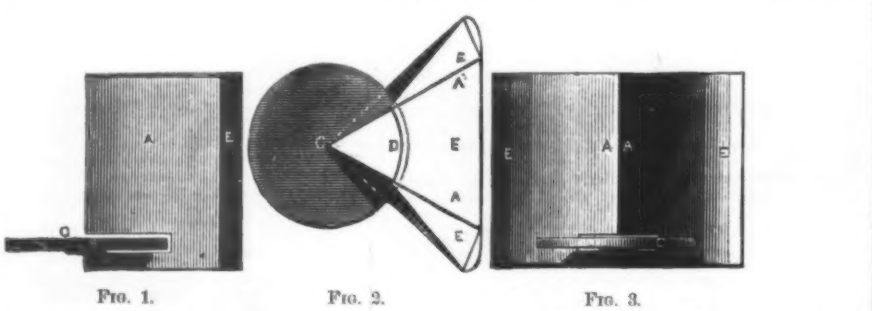


Fig. 1. Fig. 2. Fig. 3.

The mirrors, A, and pivot or bearing, B, for the disk, C, are attached to a stout framework, N, of wood, metal, cardboard, or other suitable material, which also acts as a stand for the apparatus or a place to hold it by. This framework to strengthen it is armed with side wings, E, which also act as shields to hide the edges of the tray from view. The disks at other points are fully exposed, so that thin articles can be dropped upon them; but between the mirrors of each pair they are protected by a plate of glass, D, and this glass is so cut, arranged, or painted as to form the appearance of a perfect circle. This plate, however, is not necessarily of glass; it can be of tin or other material, and be entirely open over the tray except in so far as is necessary to cover the tray edges. In this case the inner edge must coincide with the circle whose center is on the line of junction of the mirrors. The object of having disks one over the other, but each in the series of larger diameter than those above, is that objects can be placed on each, and so one set of objects be removed without the others and a perspective effect be given. It is not necessary in all cases to have disks; a simple fixed tray will do, but is a poor substitute. The mode of using is as follows: Scatter flowers, ornamental paper, or other designs on the tray or disks, and the front and top of the mirrors being exposed, look between the mirrors; shifting the disks or patterns about, a continued series of hexagonal images will result.

This apparatus can be applied to a variety of uses, such, for instance, says the patentee, as transformation scenes in theaters; in such case the mirrors are placed slightly sloping toward the audience, and the objects to be seen stand not merely on the tray, but the ground in front. In this way the apparent number of actors is sextupled.

THE POLICY OF PATENT LAWS.

By Frederic H. Betts, New York City.

[A Paper read before the Social Science Association, Saratoga Springs, September, 1879.]

Freedom of trade, in so far as regards the employment of industry and skill, was a jealously guarded maxim of the common law of England. It was one of the birthrights of an Englishman that he should not be restrained from working at any lawful trade, or using as many arts and mysteries as he pleased. [Coryton, 3; Com. Dig. Trade, Vin. Abr. Trade.]

The jealousy of courts of law of all agreements in restraint of trade is well known. In the earliest instance where such a bargain was called in question, in the reign of Henry the Fifth, a dyer was found to be bound in a penalty of £100 not to use his craft for a year. Mr. Justice Hull held that the bond was void, "for that the condition ran contrary to the common law," and, he exclaimed with an oath, and in an outburst of loyal indignation, "If the plaintiff were here he should go to prison till he had paid a fine to the king." [2 Henry V.]

Notwithstanding this underlying spirit of freedom, various forms of interference were developed by the exigencies of affairs. Among these were "the numerous and urgent statutes passed to forbid the enhancement of the prices of necessary commodities" by forestalling purchasers, and the frequent grants of monopolies by royal charter. Forestallers, engrossers, and regrators were exclaimed against as "the manifest oppressors of the poor and decayers of the rich, as public enemies, cankers, and gnawing worms that daily waste the commonwealth" [*Pulton de Pace Regnis*, tit. Oppression]; and the laws based on this spirit of hostility continued, till a late period, to form a part of English social policy.

HISTORY AND NATURE OF PATENTS.

The grant of monopolies, of the sole dealing in known commodities, or the sole exercise of known trades, were favors for which courtiers could afford to pay, and vast sums of money flowed into the royal treasury from this source. The system of monopolies was, however, an admitted infringement of the rights of the subject.

"Monopolies," says Sir Edward Coke, "were ever without law, but never without friends." [3 Inst., 182.]

The concession of the right of sole selling of articles in common use was held to be an improper exercise of the royal prerogative in Peachies' case as far back as the reign of Edward III. [3 Inst., 181]; and privileges of exclusive exercise of known occupations, of sole rights to import certain merchandise, by corporations, or to trade in particular articles, or from particular places, were early held to be beyond the law. [Roll. Abr. 212; Raym., 489.]

To a large extent, however, the power of the Crown to regulate commerce and manufactures was recognized. Even in the 14th century it was laid down by the lawyers as not inconsistent with the spirit of English freedom, that "arts and sciences which are for the public good are greatly favored by the law; and the king, as chief guardian of the common weal, has power and authority by his prerogative to grant many privileges for the sake of the public good, although *prima facie* they appear to be clearly against common right." [4 Ed. III., f. 17.] On this ground it was that the practice of the grant of patents for new inventions was originated, perhaps in the time of Edward III. The reign of that prince, who has been aptly styled the father of English commerce, was that, says Hallam, when the occupations of merchants and artificers became honorable, and many statutes were passed for the encouragement of manufactures. [Hallam's Constitutional Hist., 476.] The basis of the grant of patents for new inventions is readily understood. Lord Coke clearly stated it in the celebrated case of monopolies in the reign of Elizabeth. [Darcy *v.* Allen, Noy., R., 182.]

"When," says he, "any man by his own charge, or industry, or by his own wit or invention doth bring any new trade into the realm, or any engine tending to the furtherance of trades never before used, and that for the good of the realm, in such cases the king may grant him a monopoly patent for some reasonable time, until the subjects may learn the same, in consideration of the good he doth bring to the commonwealth, otherwise not."

In early times it was the custom to petition the king for the grant of the sole right of using new discoveries. This mode of compensation was not then a matter of right, but of grace or favor. The king, theory supposed, judged of the value of the invention and of its probable benefit to the realm, and either refused an exclusive privilege of working it, or granted it, if such favor was deemed expedient for the good of the commonwealth, or the encouragement of the inventor. This discretion in granting or withholding patents was exercised in some notable instances. Lee invented the stocking frame in 1589. Elizabeth and James the First both refused him a patent. He accordingly carried it to France, obtained there a grant of privilege, and set up his frames. It was not until 30 or 40 years subsequently that they were brought back to England by an apprentice. The statute of 21 James the First, familiarly known as the statute of "monopolies," defined the royal prerogative, and has been deemed to have insured to the inventor a legal right to a patent. Previous to its passage, as we all know, the abuse of the grant of monopoly privileges over known articles of trade had been a crying one. It had met with earnest resistance in the Parliaments of Elizabeth and James the First, but humble petitions had failed to effect a reform, and a statute became necessary. The statute of James in vehement terms declared void all monopolies, but, by its provisos, saved the grant of letters patent to the true inventor, within the realm, of any manner of new manufacture.

Since the passage of that bill the grant of patents has been substantially regarded as a matter of right. The form of the grant in England has been retained, which implies a favor from the Crown, but in practice, when the conditions prescribed by the statute exist, the great seal may not be refused. The grant is *e mero motu* in form, but *ex debito justitiæ* in fact. [Coryton, 41.]

Lord Eldon enforced the principle, easily traceable in the very origin of the practice, that patents are to be considered a bargain between the inventor and the public. The inventor, on his side, contracting to contribute a new item to the stock of knowledge of practical utility for purposes of trade; and the public, in consideration of such communication, affording to the inventor the means of retaining the exclusive use of his invention for a limited period.

The existing mutual consideration clearly distinguishes these grants from cases of the obnoxious monopolists. In the one, a benefit is supposed to be imparted to the public in return for the measure of protection afforded; in the other, the subjection of articles of common use to the control of favorites resulted in nothing but loss to the people.

The example of England in establishing a system of grants of patents for new inventions has been followed in more recent times in nearly all civilized countries. It was recognized among us during the colonial period. A decree of the General Court of the Colony of Massachusetts Bay, promulgated in 1641, prohibited monopolies, except "of such new inventions as are profitable to the country, and that for a short time." [Charter of Col. and Prov. of Mass. Bay, 1814, p. 170.] The other colonies occasionally exercised the power; and in 1789, the Federal Constitution empowered Congress to "promote the progress of science and the useful arts by securing, for limited times, to authors and inventors the exclusive right to their respective writings and discoveries."

Our first general patent law was passed in 1790; France followed in 1791; Prussia in 1815; Austria in 1820; Bavaria in 1825; Russia in 1833; and subsequently all the other European states, with the exception of Switzerland.

THE OBJECTIONS TO PATENT LAWS.

This system is, however, now arraigned as false in principle and detrimental to trade, as promotive of waste of time and talents, and as affording rare opportunities for oppression. It is to the consideration of these charges that the inquirer into the policy of the patent laws must turn his attention.

It is, then, by the opponents of patent laws broadly urged that there should be no exclusive property in intellectual products; that achievements of the mind are intended for dissemination, and ought not to be controlled by individuals; and that occupancy, the basis of all rights of property, cannot be properly predicated of the operations of the intellect. These objections have been urged both against property in copyright and that of patents, though it is conceded that in some respects the two species stand upon different grounds. Objectors of this class decline to entertain the notion that a man can have any just claim to the exclusive use of that which his mind creates, or that the results of intellectual production are to be held, as claimed by the friends of inventors, by any higher title than that of land or other visible property. These views were ably urged in the British Parliament in 1868 by Mr. Macfie, Sir Roundell Palmer, and Lord Stanley, in the discussion upon the abolition of patents.

It is to be noted that these theoretical objections are two in number: First, that as matter of public right there should be no property in ideas; and, second, that even conceding the abstract justice of such proprietorship, an invention is not property of such a nature as to admit of occupancy. In support of the first objection it is urged that "to so interfere with the communication and enjoyment of knowledge or ideas by limiting the power or right to apply inventions to use is to withhold that which one man without loss to himself may benefit his fellows; that the order of nature and the promptings of philanthropy are favorable to the communication of inventions and their free use."

This objection has a flavor of freedom and advanced thought which attracts some minds, but it has really very little practical application to the present discussion. Patent laws do not proceed upon the theory either of protecting or conferring property in mere ideas. It is only the practical embodiment of ideas in some definite and determinable shape which can properly be made the subject of a patent. The discoverer of a new principle, or of a law of nature, however useful, has never been considered as entitled to patent protection; but he who applies a discovery, in some ascertained and prescribed manner, to the improvement of trade, is, by patent laws, vested with the control over his special application for a limited period. This distinction was carefully pointed out by the Supreme Court of the United States, in O'Rielly *v.* Morse [15 How., 62]. In that case, which involved the invention of the electric telegraph, Chief Justice Taney said: "Whoever discovers that a certain useful result will be produced in any art, machine, manufacture, or composition of matter by the use of *certain means*, is entitled to a patent for it, provided he specifies the means he uses in a manner so full and exact that any one skilled in the science to which it appertains, can, by using the means he specifies, without any addition to or subscription from them, produce precisely the result he describes; and if this cannot be done by the means he describes, the patent is void; and if it can be done, then the patent confers upon him the exclusive right to use the means he specifies to produce the result or effect he describes, and nothing more; and it makes no difference in this respect whether the effect is produced by chemical agency or combination, or by the application of discoveries or principles in natural philosophy known or unknown before his invention, or by machinery acting altogether upon mechanical principles. In either case, he must describe the manner and process as above mentioned, and the end it accomplishes; and any one may lawfully accomplish the same end without infringing the patent, if he uses means substantially different from those described." The same distinction between mere ideas and their practical embodiment has been stated in numerous other cases, and reference may be specially made to the opinion of the Court in Morton *v.* The Eye and Ear Infirmary [5 Blatch., 116], which involved the celebrated discovery of the use of ether to alleviate pain during surgical operations.

THE CLAIMS OF THE INVENTOR CONSISTENT WITH NATURAL JUSTICE.

Notwithstanding the attractive position of those advocates who urge the inherent principle of freedom of ideas, a practical consideration of the feelings of men leads to the conviction that we all recognize a species of natural property in the expression of ideas, and some inherent and

natural right to prevent, in some measure, the use of our ideas by others, and this quite apart from any enactment such as a patent law. Thus, the public lecturer or teacher, though protected by no patent or copyright, resents the repetition of his lecture by another. The artist with similar feeling holds that the expression of his art idea should not be appropriated, without his permission, in the same or substantially the same form. A picture by an old master in a public gallery may be copied, because there is no one whose right of property is invaded by so doing, and because the exhibition of such a picture, and in such a place, has expressly divested it of that private character which we all feel would otherwise forbid its imitation. The common stigma which attaches to all plagiarism, whether it be in literature, art, or even in conversation, attests the prevailing sense of the right of an originator of ideas of any kind to some form, at least, of exclusiveness in their use.

If we analyze these innate recognitions of right, it will be found that mankind hold it to be just that no man should use the ideas of another, in the mode contemplated by the originator, for his own use, without giving to him that kind of return which was the motive of origination. Thus, a primary motive in all literary and artistic production is reputation. Hence, he who uses the ideas of another in literature or art, without giving credit to their true author, is felt to have infringed his right. But if the expressions be used simply by way of quotation, no right is impaired. If the production of an instructor or lecturer be repeated from memory, privately, no blame attaches; but if another attempts to supplant him before the public by reproducing his lecture, he has done wrong. The same principle and the same recognition of right is to be observed in the application of ideas to the purposes of trade. The case of trade marks is analogous. A man who originates some arbitrary name or design to indicate an article in which he trades, by virtue of his application of that idea to that particular purpose, acquires, by universal assent, by the mere adoption and use, an exclusive right to the special use of the mark, name, or brand, and all others are prevented from making the same application of the same idea; and this, not wholly on the ground of deception of the public—although that is an element—but on the basis of the right of an individual, by virtue of conception and adoption, to acquire a proprietary interest in the mark.

I say that this recognized rule of trade is not primarily based upon the idea of any harm to the public or deception of the public, for the infringement of a trade mark is equally prohibited, whether the public are in fact deceived or not, or whether the goods of the imitator be better or worse than those of the trade mark owner. [Browne on Trade marks, Secs. 393, 496, 565; Coats *v.* Holbrook, 2 Sandf., Chancery, 586.] The trade mark owner, in this case, has added nothing of value to his product by his slight exercise of ingenuity in devising for it a suitable mark; yet it is conceded that because he has adopted it, and so distinguished the goods manufactured as his own, another may not imitate the mark.

These illustrations prove that men do recognize the justice of the control by individuals of the applications and expressions of ideas; and it is believed that this recognition is in accordance with all the principles upon which the idea of property is founded.

If we apply the same principles to the inquiry in regard to the right of property in inventions, it will be seen that here too it is consonant with the principle of natural justice that he who invents something for the improvement of trade should be protected in his invention in such manner that he will receive from it the kind of return that was the motive of his invention.

It cannot be doubted but that pecuniary return is the motive of the great mass of inventions.

There are some notable exceptions, but in general it is true that few really practical and valuable inventions are the work of the mere scientific inquirer. Most are the product of the exigencies of business, and of the brains of men whose hands are engaged in the work to which the inventions relate. Mr. Webster, the author of the well known work on patents, a man of large experience, I believe, in practical questions connected with inventions, testified before the British Royal Commission in 1865: "The number of inventions brought out by really scientific people I believe to be very few, and for this reason—purely scientific people want practical knowledge to enable them to carry out their own ideas. The mass of inventions, I have no doubt, are made by workmen or persons of skill or science engaged in actual manufacture."

This, I think, is in accordance with the experience of most persons familiar with the production of inventions; and such being the class of persons who are usually inventors, it follows, as few will be disposed to doubt, that hope of advantages in trade, or to say it shortly, "money," and not the interests of mankind in general, is the incentive which creates inventions. If this be the motive of production, natural feeling justifies the expectation of pecuniary compensation for what has been invented. And here we may say, in passing, that the logical result of this feeling of justice to an inventor is best satisfied, not by a system of State rewards, which have never been found practical, but by vesting in him the exclusive control for a period of the embodiment of his ideas. For as all trade consists in the multiplication and exchange of commodities, so he who has produced a new or improved commodity is best and most logically recompensed by protection in the exclusive multiplication and exchange of that to which he has given value.

"A patent is an instance," says Bentham, "of a reward peculiarly adapted to the nature of the service, and adapts itself with the utmost nicety to those rules of proportion to which it is most difficult for rewards artificially instituted by the legislature to conform. If confined, as it ought to be, to the precise point in which the originality of the invention consists, it is conferred with the least possible waste of expense."

This view, which affirms it to be just that men should be paid for their ideas in a manner corresponding to the motive of originating them, disposes of some of the most forcible abstract positions of the opponents of patent systems. Thus, Monsieur Benard, editor of the *Journal des Economistes*, in an able article published in July, 1868, in commenting on property in inventions, and discussing the subject from the standpoint of the imagined origin of ideas of property among savage men, says:

"The first man who constructed a hut, a piece of furniture, or a cloak, was perfectly right in defending his claim to the tangible possession against any who would deprive him of it. But if this first man, not content with claiming his hut, had pretended that the idea of building it belonged exclusively to him, and that consequently no other human being had a right to build a similar one, the neighbors would have revolted against so monstrous a pretension, and would never have allowed so mischievous an extension of the right which he had in the product of his labor."

But this illustration fails because it leaves out of view the circumstances and motives which form the basis of inventions in the useful arts. The first savage who made a hut or a cloak did not do so with any view of receiving for it a pecuniary reward in trade. His motive was self-protection, and he naturally saw no interference with any rights of his, when his neighbor protected himself, likewise, from the storm or cold. But the notion of property in the embodiment of ideas, as such, is one which arises only in advanced states of society, when the arts and trade develop, and when the value of such ideas can be estimated and appreciated. And it is clear that when the motive for the origination of such ideas is the advantage to be derived by trading, in and by them, that the neighbors of the more civilized constructor will not be unwilling to recognize some proprietary right in the products of his ingenuity.

"The reasons for recognizing the rights of inventors rest," said the English Society of Arts, in 1851, "on much higher grounds than the encouragement of invention itself. They are precisely those which induce men to adopt civilized rather than savage life."

THE ALLEGED INTANGIBILITY OF INVENTIONS.

If we have now shown that property in the material embodiment of ideas is not inconsistent with natural justice, we pass to the second objection of a general nature, to wit, that inventions do not admit of being appropriated as property, because they are of a nature too intangible to be the subject of occupancy.

This objection has been necessarily in part answered in treating the former one.

We have shown that inventions are not mere abstract ideas; it is only when such ideas have passed down out of the region of speculation and been embodied in some tangible and recognizable shape that the law can or does afford its protection. Undoubted difficulties exist, and they are often grave ones, in determining the exact limits of an invention. The inventor is entitled to his original conception in the form and mode in which he has tangibly and practically expressed it, and in all other forms which are substantially the same as his. But he is entitled to nothing more. He cannot claim mere results, and so control all methods of reaching them. What he may claim is all modes which are mere colorable evasions of his own. In determining the question, however, whether a given manufacture is substantially the same as another, there are confessed opportunities for error. But these ought not to turn the scale against the policy of law whose foundation is just. These are difficulties of administration, and are due to the fallibility of human justice, and the partiality of human intelligence. The difficulty of defining the exact limits of all incorporeal rights is often very great, but it has not yet been successfully urged as a reason for their abolition.

In considering this question, the distinction between copyright and patent right has been commented upon by those in favor of the abolition of patents, but who are willing to preserve copyright. Thus Mr. Macfie, the editor of a recent volume of extracts bearing upon copyright reform, says in his preface: "There is one broad distinction between them. Copyright concerns subject matter the origin and sole creation of which can be easily determined. Patent right concerns subject matter, an invention, which may be, and commonly is, originated by a plurality of persons in complete independence and ignorance one of another, and of what each other does or has done, and which is constantly likely or liable to be improved upon both by the first and by simultaneous and by subsequent inventors. Patent right, therefore, constitutes or describes a more difficult, and, as to its justification, a more doubtful, monopoly." [Copyright and Patents, 1879.]

But the fact that the boundaries of a piece of property may be difficult to ascertain is no ground for depriving the possessor of it. Of all incorporeal rights, that of character and reputation is the most incapable of measurement; yet for that very reason it has been esteemed the most precious. The law justly protects men against the spoken word which affects injuriously their character or business name. True, the extent of injury can never be definitely measured. The trespass upon this incorporeal right may be skillfully concealed. A scandalous rebus or anagram has been held actionable [Folkard on Libel, 165]; so has a libel embodied in a *satirical* statement, or *question*, which *insinuates* a disgrace [*Id.*, 165]. But if the facts be ascertained and the result be injury to business or reputation, the law seizes upon the offender and awards compensation, and perhaps inflicts punishment. The same principle obtains in the case of trade marks, already alluded to. The simulation of a proprietary brand or name is justly regarded as within the proper cognizance of the law; and this, though points of difference may be cleverly introduced, and though cases may often arise where the most impartial may disagree as to the alleged fact of similarity of designation. In the administration of all human justice there are grave uncertainties; but the existence of numerous cases of doubt on the boundaries of all questions cannot be held to impugn the justice or policy of the principle of attempting the protection of rights so far as they are ascertainable.

THE SAME INVENTION IS NOT OFTEN MADE BY SEVERAL PERSONS.

And this leads us to the next and cognate objection to patent laws, one not abstract, as the two already stated, but practical, and closely concerning the policy and justice of the system. It is alleged that the grant of patents to the first inventor is detrimental to the progress and dissemination of knowledge, because it is rarely the case that an invention, which marks a step in the progress of the arts, is made only by a single individual, but is ordinarily arrived at simultaneously, or nearly simultaneously, by several, if not by numerous investigators. This has been already stated in the words of Mr. Macfie. The same proposition was urged by Sir Roundell Palmer in the debate on the abolition of patents. He is reported as saying:

"It commonly happened that half a dozen men who were competing in the same line of business were upon the track of the same discovery. Each of these half dozen men would probably have hit upon the invention which was wanted independently and without communication with the other; but the first who hit upon it, and who took out a patent for it, was thereby entitled to exclude the general public and competitors from the use of that which, if he had never existed, they would probably have hit upon within a few weeks. A and B reach the same point, one a week or a fortnight before the other; and A being entitled by the mere accident of such priority to exclude B from a process, which, later on, B would have hit upon for himself."

So, too, Prof. Thorold Rogers is reported as writing:

"In ninety-nine cases out of a hundred the patentee is only a simultaneous inventor, with a number of others who lose their labor and ingenuity because one man happens to get in first. It has always seemed to me that the weakness of an inventor's case lies in the fact, already alluded to, that he rarely is the sole inventor."

There is much apparent force in these statements. If, indeed, it be the case that ordinarily the same invention is hit upon by a number of persons, and that the world is not really indebted to any single individual, but that it can obtain the same advantage from a number of sources at nearly the same time, is it, on the whole, a just or sound policy to place the sole control of the invention in the hands of the one who, by special diligence or by happy accident, arrives first at the goal? In considering this question it must be borne in mind that the principle of rewarding those whose only claim is priority is not confined to patent laws. We have already adverted to the law of trade marks, where the first adopter of a given symbol for a given class of merchandise is recognized as entitled to its sole use for that purpose, and this entirely irrespective of the question of good faith, ignorance, or otherwise, on the part of a subsequent adopter. So, too, the claim of governments to lands, by virtue of priority of discovery; and in mining laws, the right to mining claims founded upon the same principle; the same rule is adopted in bestowing rewards for excellence in nearly all cases of competition. It is he who is first to reach the goal, or he who evinces the highest capacity in any department, who carries off the prize. The next competitor, however closely he may press the winner, is little recognized. Priority is always compensated to a degree vastly out of proportion to relative excellence. But if it be conceded that the proposition is true, which affirms that inventions are ordinarily made by a number of persons simultaneously, it must be remembered that this proposition is only alleged to be true under the operation of the patent laws, by which an incentive is held out to induce invention, and the prize of a patent is offered to him who shall first invent and perfect. Is it true that under a system where there are no patents, and no such incentive exists as they afford, that a number of persons will be working simultaneously at the same problem, and will reach the same result in close proximity in point of time? Is not the comparison to be properly made between the state of affairs as it now exists and a condition of things, where the inventor expects no control over his invention? If it be the case that three, four, or more persons are ordinarily competing for priority, is not that state of affairs the product of the patent system? And do not all of the competitors strive under the well-understood condition that "they that run in a race, run *all*, but *one* receiveth the prize"? If this be so, can it be justly claimed that the grant of patents deprives the country of the free use of what they would have obtained in any event in a short time? Is it not rather rational to conclude that the competition of numerous investigators, who understand that it is to the first, only, that compensation is offered, results in the production of a desired object at a period so far in advance of that at which it would otherwise have appeared, that the country can well afford to pay a handsome premium in royalties for its early revelation?

But it is difficult to say that the proposition is well founded, which affirms that the same invention is ordinarily hit upon about the same time by a number of experimenters. There has been much loose and half-understood statement upon this subject. My own experience has led me to the conclusion that it is very rarely the case that the same invention is simultaneously made by several. It is true that there are times when, as has been said, the whole atmosphere of thought seems to be quickened by the sense of an impending discovery. It is also true that independent investigators sometimes announce their accomplishment of the desired result with substantial contemporaneity. But it will be found in most of these cases that it is only the result which is the same with the several searchers.

Only in that can the inventions be deemed the same. In the aspect in which they are viewed by the patent law they are totally distinct and different. While each person has solved the same problem, the method adopted and the means employed by each have been quite dissimilar; and as results cannot be patented, it turns out that each is entitled to claim and hold his own ascertained mode, and neither is invested with control over the other, except what may naturally result from superiority of one method of treatment. The notable case of the invention of the electric telegraph will illustrate the correctness of this statement. The scientific world was in the early part of the third decade of this century laboring over the problem of electric communication. A hundred minds were engaged in studying recognized phenomena, and seeking to unravel the mystery of conveying intelligible signals to a distance. If there ever was a case where, according to the favorite statement of the opponents of patents, it might be expected that there would be simultaneous and identical inventions, here would apparently be an instance. As matter of fact, Prof. Morse in America, Prof. Wheatstone in England, and Monsieur Steinheil in France, in ignorance of each other's discoveries, announced the solution of the problem at nearly the same time, yet each of their inventions was distinct and clearly distinguishable from the other in character. No one of them could, under the principle of patent law, already explained, claim the control broadly of the communication of signals by electricity. Each was entitled to exclusive property only in his own special device, with the right to suppress other devices which were substantially equivalent. In comparing the contrivances of Morse, Wheatstone, and Steinheil the Supreme Court of the United States said:

"It is impossible to examine them, and look at the process, machinery, and results of each, so far as the facts are before us, without perceiving at once the substantial and essential difference between them, and the decided superiority of the one invented by Prof. Morse."

I am satisfied that the cases of real, complete, and perfect inventions of the same thing are comparatively rare. It is undoubtedly true that nearly every patent case develops in its defense opposing claims of rival inventors, and a variety of contesting competitors for the honor of the invention. But I think I appeal to the experience of the great mass of patent lawyers when I say that, in the vast majority of cases, the alleged inventions, relied on as defenses, are abortive and unsuccessful experiments which never did, and, probably, never would have culminated in anything of practical value. In deciding the celebrated case of Goodyear *agst.* Day, relating to the patent for vulcanized rubber, Judge Grier used these memorable words:

"When genius and patient perseverance have at length succeeded, in spite of sneers and scoffs, in perfecting some valuable discovery, how seldom is it followed by reward? Every unsuccessful experimenter who did or did not come very *near* making the discovery now claims it. Every one who can invent an improvement or vary its form claims a

right to pirate the original discovery. We need not summon Morse, or Blanchard, or Woodworth to prove that this is the usual history of every great discovery or invention. The present case adds another chapter to this long and uniform history. But, notwithstanding the indomitable energy and perseverance with which this attempt to invalidate the patent has been pursued, the volumes of testimony with which it is oppressed, and the great ability with which it has been canvassed in the argument, we are of the opinion that the defendant has signally failed in the attempt to show that himself or any other person discovered or perfected the process of manufacturing vulcanized rubber before Goodyear."

I am indebted to the able argument of Mr. Storrow, of Boston, before the Committee on Patents of the House of Representatives, during the consideration of the proposed new patent law in 1878, for the following statement, which may, I think, be relied on as indicative of the same truth. Mr. Storrow said:

"It is said that many inventions are made simultaneously, that different men in different places make the same invention at the same time. That is not the fact. Undoubtedly it has happened from time to time that several men striving in the same branch hit upon substantially the same devices; but the cases are comparatively rare. The best proof of that is, that in not one of the industries (The weavers, the hosier, the shoe trade, the steel works, before spoken of by the counsel) will you find any one man at any one time inventing a complete thing. If the invention to be made was a single distinct thing I could conceive of simultaneous inventors; but not when the perfected machine, the thing accomplished, is the result of years of work and many inventions. We have a way of ascertaining some proof about this from the Patent Office. There are filed in the Patent Office 20,000 applications a year; and I think I rather understate it in saying that each one of the patents contains three claims on an average for three distinct things—separate devices. If that be so, there are 60,000 claims filed in that office in the course of a year by men who swear that they are the original and first inventors thereof. Now, there is a process by which if one man overlaps other claimants an 'interference' is declared; and how many out of this large number are put into interference in the course of a year? Last year was the highest number, and that was 614."

This illustration of Mr. Storrow may be further examined. By far the most common case of interference is between employers and workmen; between the man who furnishes the ideas and the man who puts the idea into a machine; between the deviser and the constructor.

It frequently happens that when two or more men are engaged in aiding each other in perfecting an invention each considers himself the real inventor, and underestimates the services of the others. Each applies for a patent for the same device. Often, too, interferences are produced by fraudulent attempts of one man to purloin the invention of another.

None of these are cases of independent inventions; and if we deduct these large classes, and that other considerable number of cases where, in the progress of the contest, it is found that no real interference exists; that the supposed competitors are really inventors of distinguishable and separate improvements, it will be found that instances of rival and contemporaneous claims between really independent inventors are among the rarities in the history of invention.

Much more might be said on this important branch of the inquiry, but we must pass to another difficulty.

PATENTS DO NOT OBSTRUCT THE PROGRESS OF SCIENCE AND THE ARTS.

It is urged, then, that the system of granting patents does not in reality "promote the progress of science and the useful arts," but that they are really obstructive of industrial improvement.

If this indictment be a true bill it is indeed fatal to the upholders of the policy of such laws, for it strikes at a principal reason which has been alleged for their enactment.

The obstructiveness of patents is alleged to manifest itself principally in two ways. It is said, first, that the man who originates a vital idea, which lies at the basis of any given industry, has it in his power to suppress all subsequent improvements which must, if they come into use, be grafted upon his invention. Thus, Howe, the inventor of the eye-pointed needle in combination with an automatic feed, and who thus laid the foundation of the sewing machine art, had it in his power, it is said, to prevent for 14 years the manufacture of improved forms of sewing machines.

This supposed power, vested in the owners of fundamental patents, somewhat impressed me when the subject was first considered. Subsequent thought and experience have, however, diminished in my mind the importance of this consideration.

In the first place, the natural anxiety of manufacturers to supply to customers the best form of article in their power tends to counteract any tendency in the opposite direction. It is always known and felt that patent privileges are only of limited duration. The period of the expiration of the fundamental patent must be foreseen and provided against. It will not do for a manufacturer to follow too rigidly a set form, lest competitors succeed in securing improvements which will in the end supplant his business and render of no value vast accumulations of capital and machinery. Trade demands novelty. Popular taste can only be attracted and held by the allurements of variety and improvement. New inventions are always of more value to a manufacturer of established business, in the department to which they relate, than to any one else; and the wish to secure custom by the attractions of improvements leads to their purchase by prudent manufacturers.

At all events, under a patent system an invention becomes a thing of marketable value, and, as a rule, I believe that improvements, which can be thus secured, are welcomed and fairly paid for by business men.

I have already adverted to the fact that the majority of inventions of real value are made by practical workmen under the stimulus of the requirements of business, and often at the request of employers. The hosiery business in England is an instance of this state of affairs. It is sometimes cited as an exceptional one, but I believe it to be less so than it is thought. It was stated by Mr. Storrow before the House Committee already referred to, that "it is the practice in that industry for the manufacturers to encourage the workmen to make inventions, and the consequence is that the inventions which have revolutionized this branch of industry have been mostly made by the superintendents and foremen, the skilled workmen of the establishment.

"One of the large manufacturers is Mr. Mundella, who has been in Parliament. Mr. Mundella said he asked one of his men who had made a good invention, and who had worked on it a good many years, as to what he would have done if he could not have got a patent. 'I should have gone to America pretty quick,' said the workman. Mr. Mundella said he had received the same answer from at least fifty men."

It was stated before the same committee, on behalf of the Shoe and Leather Association of Boston, that they were willing to adopt inventions even when they originated outside of their industry.

"The gentlemen we represent," said their counsel, "are not the owners of patents; they are not the owners of inventions, but they have desired, and do desire, to be just to these men who originated these inventions; and we must admit that they generally have been made by persons outside of the business, who had the genius or spirit of invention, and they have been adopted by manufacturers after being brought to their attention. Now, it is but just and due to the inventors, and we desire frankly to acknowledge our great indebtedness; certainly we should not now occupy our present position in business were it not for these inventions, and these inventions would not exist unless patented by some patent law."

But again, if a patent law is properly administered, the owners of fundamental patents do not acquire any absolute power to suppress subsequent improvements.

A patent grants to the inventor the exclusive right to make, use, and vend the invention, but if this right is infringed, the remedy is solely within the control of the courts. The patentee must bring his action at law for the damages occasioned by the trespass, or proceed in equity for an accounting of profits, and an injunction to prevent further infringement. The recovery of either damages or profits by the patentee is, however, always limited to such portion of the whole loss to his business, or such portion of the whole profit realized by the infringer, as may be proved to be due to the adoption by the infringer of the patentee's invention. A patentee is not entitled to claim anything that may be realized by an infringer from the use of the infringer's own improvements.

Hence, so far as the infringer may be compelled to pay for his action, he is obliged to pay only the fair value of the property which he has appropriated. But he is not in any way accountable for the effects of his own beneficial modifications.

The process of injunction, it is true, might, and perhaps has been, used by the courts to suppress valuable improvements; but if this be the case, it is an evil of judicial administration under the law, and not an evil of the law itself. The too free use of the prohibitive injunction may be productive of serious prejudice to trade, but injunctions may always be regulated with wise discretion. They are never a matter of strict right; they are always within the control of the equity judge.

In Howe *v.* Morton [1 Fisher, 586], where the patent of Elias Howe for the sewing machine was involved, Judge Sprague adverted to this discretionary power of the court. "The machines of the defendants," said he, "are supposed to embrace improvements upon Howe's, which could not be used without using the original upon which they are engrafted. These improvements may greatly increase the utility of the machine. The court will not unnecessarily prohibit a party from using his improvements. If the defendants will give security to account and pay to the complainant such sum as the court shall decree, injunctions will not issue."

This is a sound and wise policy to be kept in view. It has been sometimes forgotten. A proper balance must be preserved between the practice which would use judicial process so as to defeat the avowed motive of the constitution and law "to promote the progress of the useful arts," and one which would withhold such just and summary protection, as can be fairly afforded, to patentees.

THE ALLEGED ANNOYANCES FROM PATENTS.

But, second, it is objected to the practical working of patent laws that they are often made the means of annoyance and oppression to persons in business. Grievous complaints are made on the part of both manufacturers and users of articles, that they are subjected to threats and to prosecution, under the patent laws, for dealings which they have entered upon innocently, in entire ignorance of the fact that they have been infringing upon a patent. Undoubtedly great annoyance of this kind has been endured by the business community, and wrongs have been sometimes perpetrated under the pretensions of patent rights. The owner of a patent may, under our present system, bring suits against innocent customers of an infringing manufacturer, or against individual users of patented contrivances, whose separate interests in opposing such suits are too trivial to justify a defense. A large part of the outcry against patents in this country has been made by people smarting from real or imagined injustice of this kind; from the victims of claims for infringements of driven wells, or harvesters, or farm gates.

Evils of this kind will, however, in the end correct themselves. If the claims of patentees are just, no great wrong is occasioned by compelling the user to pay for the value of the advantage he receives. If they are unjust, the remedy will be found in the wider diffusion of knowledge, and in the growth of that spirit of association for mutual defense which has already corrected many of the oppressions exercised upon the many by the few. It was wisely remarked in the proceedings in Congress, already quoted from, that "most of the objections to the patent system resolved them selves into ignorance of what the patents are, or what the system is. The cases of hardship which you hear of, nine times out of ten, are submitted to because the party does not know enough to defend himself, or does not know enough to refuse to buy a patent which is not worth what he gives for it. If you have an excellent machine, and your operative cannot work it successfully, you do not destroy it, you teach him about it, and the remedy here is largely to disseminate education on this branch in the community, and that is being done very fast."

This latter statement it is gratifying to believe is true. Our law provides for notification of the existence of all patents by making them public records, by publishing weekly their claims as they are granted, and by requiring all manufacturers of patented articles to give notice of the fact that they are patented, by affixing to them a stamp indicating that fact, together with the date of the patent relied upon. It is moreover true that it is the growing practice for manufacturers not to enter upon any branch of manufacture until they have investigated carefully the questions which may arise under existing patents, and to keep themselves apprised of the progress of inventions, and of the issue of patents, by having furnished to them, weekly, by the Patent Office (as it is prepared to do at a small cost), copies of all patents relating to their class of industry.

Doubtless, however, there will always be cases of tribute levied upon unsuspecting persons by patentees, and "black mail" will sometimes be demanded under pretense of a patent right. Laws will be always used by unscrupulous persons in this manner; but the fact that they are so used, if they are inherently just and tend to promote their object, cannot be urged as a reason for their repeal.

"We want government, though it entails disagreeable taxation and abuses in its administration. We must have courts of justice, though they sometimes decide wrong." [Congressional arguments, 159.]

SUPPOSED USELESS INVENTIONS.

But, again, it is contended that the pursuit of an inventor is one largely of disappointed hopes; that the Patent Office is a vast repository of the records of wasted effort, thought, and expectation; that the inventor rarely receives any compensation, owing to the expense of legal proceedings; that altogether the balance of profit and loss, to an inventor, is, on the average, on the wrong side of the account.

That the hopes of inventors often fail is proverbial. Most of them, I believe, over-estimate the importance and probable profitableness of their own inventions. It is curious to note that the very earliest account that we have in the English books of the grant of a patent is the story of a supposed discovery, which in fact ended in disappointment. It is related in the Parliament Rolls of Edward the Third "that some alchemist pursuaded the king that a philosopher's stone might be made; and the king granted a commission to two aldermen and two fryers to inquire if it was feasible, who certified that it was; and the king granted to the two aldermen a patent of privilege that they and their assigns should have the sole making of the philosopher's stone." [Note to Darcy *vs.* Allen, Moore's R., 675.] The expectations of the alchemists and the aldermen were doomed, and so are, alas! the hopes of vast numbers of inventors. But it must be remembered that many inventions are of small things and only call for small returns, and it is yet to be proved that there is a greater proportion of *total* failures among inventors than in other departments of business. Not one man in ten succeeds in any of the ordinary pursuits of trade. Not one venture in fifty yields a return. The law of all development and growth is a law of many failures to a single triumph. So it is in nature. A thousand acorns utterly perish while one perfect oak is grown. A myriad creatures have had their little day, and died in the progressive development of species. This law of apparent universal waste of force in the operations of nature is the riddle of the philosopher.

The skeptic cites it as a proof of the absence of the all-wise and personal government of God. The Christian poet has answered in the glowing thought that all is not lost that seems to die, but that—only,

> "So nature, in observance sweet,
> Like Mary, breaks the fragrant spice
> Of treasured life upon His feet,
> Not waste, but, costly sacrifice."

In harmony with this thought it is to be observed and considered that failures of inventors are not total failures, and that the system which stimulates them to invent, even though for a time they produce nothing valuable, is not a useless one. He who is induced to commune intently with nature or with art learns other lessons than those immediately proposed. The eye which is strained to pierce the mist, which shrouds one object, catches side views of others. Mental training, sharpened perceptions, clearer understanding of difficulties and their remedies, result from setting a motive before the inventive faculties.

Though efforts are for a time fruitless, yet the labor is disciplinary. Mr Chauncey Smith stated before the Committee of Congress, in 1878, an important truth when he said: "It is often through failures that men learn how to succeed. Watt said it was a great thing to find out what could *not* be done. I have often been astonished at the great amount of scientific and technical knowledge possessed by our mechanics, at the acuteness of their observations, the activity of their imaginations in forecasting results, and their fertility in expedients and the soundness of their judgment in all things pertaining to the properties of matter, and the laws and operations of nature. They carefully watch for the results of the labors of scientific men in their fields of research. They are familiar with what has been achieved in those fields, and are diligently laboring to turn their knowledge and acquirements to practical account. It is no unusual thing to have a common mechanic, explaining some invention of his own, refer to the researches and discoveries of such men, for instance, as Tyndall and Sir Wm. Thomson. It is to our patent law, which has given to such knowledge a practical value in the hands of these men, that we are indebted for the possession of the most intelligent and skillful body of laboring men in the world—a body of men who, having overcome the disadvantages to which this country was subjected by its want of capital and cost of labor, has placed within our grasp, as I fully believe, a large share of the manufacture of the world."

COSTS OF PATENT LITIGATIONS.

But space forbids us to answer in detail other objections to patent laws that have been discussed. The expense of patent litigation is a notorious evil; but it is an evil of administration under the laws, and not a vice in the principle of patents. It can, and, I believe, will be, remedied by the introduction of more simple and summary forms of procedure. The uncertainty of rules for the recovery of damages for infringement has been dwelt upon as a wrong, but it is a fault of detail. The new patent law, already proposed to Congress will, I am satisfied, after consideration, remove much of the difficulty.

EFFECT OF PATENTS ON PRICES.

The complaint that patents raise the price of commodities is asserted and reiterated, but is generally untrue. A patent never does raise the price of a new thing; for being new, it had no former price. Large numbers of patents are in the line of labor-saving machinery, which always diminishes the cost of production, and cheapens selling prices. It could be shown, by an examination of all our principal industries, that the tendency of patented inventions has been, nearly everywhere, to increase the wages of the workmen, while it diminishes expense to the consumer.

THE BENEFITS OF PATENT LAWS.

Having now considered some of the principal objections to the policy of patent laws, it remains to point out some of the advantages of the system. And first, a patent is not only a stimulus to invent, but it is the reward of the publication of the invention. The inevitable tendency of the absence of a good patent law is the attempted concealment of inventions.

In Prussia, *a very defective* system has had that effect. Count Bismarck, in his message to the North German Parliament in 1868, admitted the practice of secrecy by inventors as "a recognized fact," and attempted to argue from it that patents might in Prussia be wholly abolished without further detriment. It is said that the famous Prussian steel manufacturer, Mr. Krupp, relies upon secrecy for the protection of his business. This attempted secrecy is of immense detriment both to the public and to inventors—to the public, for obvious reasons if the secrecy is effectual. This was the case with the invention of silver electro-plating, probably practiced by the father of Mr. Bessemer, the steel manufacturer, and not rediscovered or practiced until many years afterwards by the Elkingtons. To an inventor, because the attempted secrecy is rarely effectual. Mr. Bessemer, the son, was asked what he would have done in regard to his celebrated steel process if there had been no patent law. "I never would have spent a pound of my money or an hour of my time."

"Would you not have worked in secret?"

"How could I work in secret an invention requiring a plant costing a million, and requiring a great many hundred men to run it?"

An English manufacturer, who was asked the value of the secret practice of inventions, said, that he was not sure that a pot of beer would disclose any secret process, but he knew that two pots would.

GROWTH AND PROGRESS OF IDEAS IN RESPECT TO PATENTS.

As bearing upon the question of the benefits of patent laws, there is to be noted a remarkable correspondence between the establishment of patents, the periods of growth in a proper understanding of their nature, and in liberality of treatment to patentees, and the times of progress of mechanical and scientific industry. The end of the last century and the present one has been the great era of mechanical improvement; and it is precisely this period that has witnessed the establishment of the patent system. Though the patent law of England was placed on a definite footing by the statutes of monopolies in 1623, patents were for a long time few in number. In the first fifty years hardly as many patents were granted, and in the 115 years from 1675 to 1790, the year of our first patent act, only 1,684 patents issued, an average of less than 15 a year. Previous to the time of Lord Eldon in England, about the beginning of this century, patentees were still regarded in the courts of law rather as creatures of royal bounty, and nearly as much subjects of criticism and disfavor as the monopolists of the Elizabethan age. "Language was sometimes employed by judges," says Mr. Coryton, "in the application of the doctrine, which would at the present day be considered highly unconstitutional." [Coryton on Patents, p. 33; *ex parte* O'Rielly, 1 Vesey, Jr., 119.] . . . "A narrow and jealous spirit was suffered to prevail in dealing with the results of commercial enterprise and manufacturing skill." . . . "The nature of the patentee's privilege drove him frequently into courts of law, and during this early period almost constantly to his disadvantage."

I remember no case where a patent was sustained by the courts prior to the last half of the 18th century. [Dolland's case, 1766, 1 Webb, p. C. 43.]

Even as late as 1785, the patent of Mr. Arkwright for his celebrated cotton spinning machinery, one of the greatest gifts to his country, was held invalid and canceled on technical grounds.

"To the patentee alone no margin was conceded for possible error. An unapt title to his invention, an ill-judged word in its description, an incautious experiment, the least disclosure of his secret before letters sealed, and his privileges were at an end. Technical rules framed with other objects, and unsuited to the case, were rigorously applied by those who saw in it only the relation between the sovereign and the subject, and adjudicated on the maxims of the common law, as applicable to royal franchises and grants, while the merits of the invention, or its effect on public policy, rarely engaged attention." [Cory. on Patents, p. 48.]

But in the end of the century a more liberal spirit began to pervade the country. Watt had invented his steam engine in 1763. It had been patented in 1769. In 1775, Parliament had extended the term to 24 years, and in 1799 it was sustained by the courts [Hornblower *v.* Boulton, 8 T. R., 95,] after a mistrial in 1795 [2 H. B., 463], Mr. Justice Baller, in 1787 [Turner *v.* Winter, 1 T. R., 602], stated an opinion which showed the turning of the tide in favor of patentees.

"Whenever," said he, "it appears that the patentee has made a fair disclosure, I have always had a strong bias in his favor."

Lord Eldon, in 1800, laid down the doctrine that "the patentee is a purchaser from the public," a doctrine, as Baron Alderson said, that involved the principle that "patents are to be considered as bargains between the inventor and the public, to be judged of on the principles of *good faith*, as are all other bargains."

This development of a true appreciation of the rights of inventors was not a mere change of sentiment, but followed upon a better understanding of the nature of trade, and of the proper province of laws in relation to it. As early as 1767, the rising spirit of intelligence had showed itself in the House of Commons in a resolution against the old laws relating to forestallers and engrossers, which had so long formed a part of the English system.

While these forms of interference with trade were abolished, the policy of granting patents was approved and enforced.

NUMERICAL INCREASE OF PATENTS.

The announcement of the decisions in the last decade of the century was felt in the growth of inventions. From 1790 to 1800, the average number of patents rose to 70 a year; from 1800 to 1815 they averaged 100. In 1830 they were 150. In 1840 nearly 600; in 1852–3, the first year of the patent law amendment act, 2,420. The present number is about 3,500.

All will recognize these periods of increase as contemporaneous with industrial progress. The present century has produced more than all other centuries of English history put together. Trade and the facilities of trade have increased in the last 50 years more than in all the history of the world besides; and this amelioration has been by means of and because of patented inventions. The spinning frame, the power loom, the steamboat, the locomotive, the improved printing press, the Bessemer steel process, and numerous others, attest the close relation of patents.

Simultaneously with the new tone of feeling in England came the establishment of the patent system in the United States and in France. In France it was born with the spirit of freedom. It was the decree of the French National Assembly of 1791, that, "not to regard a discovery in industry as the property of the discoverer, would be to attack the rights of men in their essence." [Coryton, p. 37.]

Our industrial progress has been developed, *pari passu*, with the increase of patents and the liberality of their treatment. The notable inventions that America has produced during the present century are familiar to all. I need hardly mention Whitney's cotton gin, Woodworth's planer, Blanchard's machine for turning irregular forms, Howe's, Wilson's, and Batchelder's sewing machines, Morse's telegraph, Goodyear's vulcanized rubber, McCormack's mowers and reapers, Simpson's submarine cable, Edison's duplex and quadruplex telegraphs, Colt's revolvers, Hoe's printing press, steam pumps, paper bag machinery, nail and pin machines, and all the countless appliances which minister to modern life.

The decades of inventive activity have been marked by a parallel increase in the number of patents. Prior to 1836, we had granted only about 10,000 patents; since then, upwards of 200,000; and it will be seen, on examining statistics, that the material growth of the country has been largely proportioned to the increase of inventions. I have not space to state figures, but some exceedingly interesting ones were placed before the Congressional Committee of 1878. Now, what does the fact that our manufacturers increase with the number of patents show? It would be a narrow view to contend that the patent system has been the cause of all of our material progress. There has been abroad within the present century a widespread spirit of activity, which the learned German historian, Von Ranke, calls the Genius of the West—"the spirit which converts nations into disciplined armies, which makes roads, constructs canals, appropriates the seas, covering them with ships, colonizes distant continents, explores the arcana of nature, occupies all the domains of knowledge, and renews them with ever added achievement."

But it may be, at least, contended that the statistics show that patent systems are in accordance with this spirit of achievement; that our manufacturers are using newly invented contrivances, not depending upon old methods, however approved they may have been; that inventors find it profitable to invent, and that there is a demand for the exercise of their talents, and a market for their intellectual products; and this, notwithstanding all that is said of the fact that inventors are poor and ill paid, and are ordinarily cheated of their emoluments.

HOW PATENTS PROMOTE TRADE.

Patents and trade go hand in hand. Take away the motive of invention and you destroy an important ally of improvement. It is said that inventors always will invent; that inventions come when they are needed, and common phrase makes them to be, as it were, automatically evolved out of the necessities of business. Inventions do *not* come merely because they are needed, but because they are needed and will be paid for, and it is only by making them property, and protecting them as property, that they are worth purchase. They are influenced, like other things, by the law of supply and demand; but the law of supply and demand does not operate where there is no inducement to supply, and no payment accompanies the demand. Demand must come with purse in hand, or supply does not respond. The patent system is based upon this fundamental law of political economy. Inventions do not come when and merely because they are called for, as by the stroke of a magician's wand. Long years must perhaps be spent in study and costly experiment. A premium was offered for a steam engine by Charles II., but Watt only produced one under George the Third. A steam plow has been a desideratum for a generation, but the demand has not yet produced the supply.

EXPERIENCE APPROVES PATENT LAWS.

Now, in closing, let me note that the longer we have experience with the patent system, the stronger are the hands of its advocates. There was a period when it became the fashion in high quarters to look askance at patent laws. In 1865, when the Royal Commission reported on the subject of patents, Lord Stanley, the chairman, said:

"The House ought, first, to have an opportunity fairly and deliberately of deciding upon the larger question which had not been submitted to the Patent Law Commission, viz., whether it was expedient that patents for invention should continue to be a part of the law."

In 1868, in debate he said "he was convinced that the patent laws did more harm than good, and, if called to say aye or no as to their continuance, he should certainly give his vote against them." Yet to-day the papers report that the English government is considering whether it will not lengthen the term of all patents to 21 years.

In December, 1868, Prince, then Count Bismarck, in a message to the North German Parliament, strongly indicated that it was the opinion of the Royal Prussian government that the patent system should be completely abolished; but the German Empire has, within the last year, passed a comprehensive and efficient patent law, based in part on the English practice, and in part upon our own.

In 1868, before the Glasgow Chamber of Commerce, it was solemnly urged that patent laws "give a factitious impulse to the inventive faculty, destroy the natural equilibrium of capacities, and foster a scheming fanciful turn of mind at the expense of thoroughness and of patient working out of sound ideas." "This result," it was then said, "has actually occurred in the United States, where the factitious value attached to invention has tended to produce an almost total sacrifice of solid workmanship, and a flimsy ingenuity."

In 1876, however, Sir Wm. Thomson, President of the Mathematical and Physical section of the British Association, in reporting upon our Centennial Exhibition said:

"If Europe does not amend its patent laws, America will speedily become the nursery of useful inventions for the world."

Mr. Hulse, the English judge of textiles, at the Centennial, reported to Parliament:

"As regards the extent of invention and ingenuity, the United States was far ahead of other nations. I do not remember any exhibitor who had not features of novelty and ingenuity to claim in the machines he exhibited. The extraordinary extent of ingenuity and invention existing in the United States, and manifested throughout the Exhibition, I attribute to the natural aptitude of the people, fostered and stimulated by an admirable patent law system."

And again: "One cannot fail to notice the great fertility of invention displayed in America, and the *excellent workmanship* obtained by the joint effect of their tools, machinery, and skilled workmen. . . . The American patent law must be admitted to be most successful, and the beneficence of its working was very amply illustrated throughout the American section of the Exhibition."

For many years the opponents of patent laws have cited Switzerland as a prosperous state without a patent system, but which freely availed itself of the inventions of the world. Its artisans were said to need no stimulus to invent other than the ordinary competitions of trade; and its freedom from patent monopolies was to them an oasis in European legislation.

But in 1876, our universal Exhibition opened the eyes of the Swiss themselves to the benefits of patents. Mr. Edward Bally, one of the Swiss Commissioners and himself a large manufacturer, addressed a paper to his co-patriots, in which he said:

"We must introduce the patent system. All our production is more or less a simple copy. The inventor has no profit to expect from his invention, no matter how useful it may be. It is evident this absolute want of protection will never awaken in a people the spirit of invention, but on the contrary, accustoms them to copy, more and more, that which belongs to their neighbors, and that is not to the honor of the country. The want of protection for new inventions is a disadvantage to us. The state ought not to hesitate to add to its resources this new resource; but at the same time, we must remember that an invention is valuable in proportion to the facility with which it can be made available. And so it is essential that the grant of patents be accessible to inventors of the most moderate fortunes. America has shown us how, in a few years, a people in the midst of circumstances often embarrassing can merit by its activity, its spirit of enterprise, and its perseverance, the respect and admiration of the whole world, and acquire in many respects an incontestable superiority. May our sister Republic serve as our model in this."

Do not, therefore, the teachings of experience pronounce the policy which has created, upheld, and liberalized patent laws, on the whole, a just and a sound one—a policy which ought not to be abandoned, but one which should be enforced by the more general diffusion of an understanding of their meaning and scope, and by the simplification of practice and remedies relating to them?

"I have seen," says Mr. John Stuart Mill, "with real alarm, several recent attempts, in quarters carrying some authority, to impugn the principle of patents altogether—attempts which, if practically successful, would enthrone free stealing under the prostituted name of free trade, and make the men of brains, still more than at present, the needy retainers and dependents of the men of money bags."

STEEL.

Opening address, August, 1879, by J. ROBINSON, Pres. Inst. Mech. Eng., President of Section G, British Association.

ON THE DEVELOPMENT OF THE USE OF STEEL DURING THE LAST FORTY YEARS, CONSIDERED IN ITS MECHANICAL AND ECONOMIC ASPECTS.

MUCH has been written by poets and others of a succession of the ages of the human race in comparing their degradation with the various kinds of metal, considered metaphorically—thus we have the golden age, the silver age, the age of brass, and the age of iron.

Our own time may very appropriately and literally be described as a branch of the latter age, and be named the age of steel.

In the metropolis of the steel manufacture it would seem fitting that the Mechanical Section of this great scientific association should direct its attention to this wonderful metal, the uses of which are daily becoming more numerous and important.

But it may be said, on the other hand, that as the use of this material is perpetually growing more common, so are discussions as to its manufacture, composition, and characteristics becoming almost wearisome from their frequency.

Notwithstanding an appearance of truth in this objection to our occupying more time in referring to the subject, I would venture to entertain the hope that a treatment of the question in its mechanical and economic aspects may prove not uninteresting to this meeting.

At the time when railway extension was becoming general, about forty years ago, the use of steel in this country was confined mainly to tools for mechanical purposes, including files and other articles, springs for vehicles, weapons of various sorts, and implements for agricultural and domestic uses; and it is proposed to measure the scientific and mechanical energy brought to bear upon the manufacture and improvement of this metal by the increase in the number of purposes to which it is applied, and the diminished price at which it can be obtained, as compared with the price at the time of its introduction for constructive works. There are, however, several important exceptions to this method of appreciation to which reference will hereafter be made.

We will take, then, the simplest form in the preceding list, viz., *tool steel*, the price of which for ordinary purposes varied from 50s. to 56s. per cwt. at the period I have named; and we shall find that the development of the manufacture of steel in general has but little affected this particular material, which is still produced in much the same fashion, *i.e.*, by the use of carefully selected Swedish iron, carburized by exposure in ovens to the heat of burning charcoal, and then recast from crucibles and hammered down to the required size. The result of a somewhat stationary condition of manufacture has been the maintenance of prices, at the same, or about the same, level up to the present time.

A superior quality of tool steel has been produced by the adoption of a process invented by Mr. R. Mushet, in which titanium is introduced in the manufacture, and which dates back to the year 1838–39. This steel is of great endurance when applied to the working of steel and iron of considerable hardness, and its higher price of 140s. per cwt. is quite justified by the excellent results obtained from its use, and other steels of similar fine quality are produced by several manufacturers, who make specialties of them.

Some twenty-seven or twenty-eight years ago, Krupp, of Essen, gave an enormous impulse to the application of steel, by his method of producing much larger masses of crucible steel than had previously been possible. He at that time accomplished the casting of an ingot of "crucible" steel of 50 cwt., a weight then considered incredible, and this was followed up by the production of weldless cast steel tires in 1853, which led to the very rapid development in the use of his steel for railway tires, cranked axles for locomotive and other engines, straight axles and shafts, and parts of machines in general.

It is most interesting to consider the prices of such of these objects as have up to this time maintained similar forms, with the object of ascertaining by the selling price, the progress in the scientific and mechanical appliances used for the production of the materials just referred to.

At the time of their coming into use, about twenty-five years ago, the price of cast steel tires was 120s. per cwt.; it is now from 18s. to 25s. per cwt. The price of forged steel

cranked axles was, when first introduced, £15 per cwt.; it is now from 65s. to 70s. per cwt.

The price of straight axles and shafts was from 40s. to 50s. per cwt., it is now from 19s. 6d. to 23s. per cwt.

Now to what do we owe this enormous reduction of price and consequent more frequent and more economic application? The answer must be that, following the initiation of Krupp, our English engineers and men of science set themselves to work to discover and apply new processes for the production and manufacture of this most wonderful metal; and I venture to say that in the whole history of metallurgy, from the time of Tubal Cain downward, there has been no such progress in invention and manufacture as has been realized by the aid of such men as Mushet, Krupp, Bessemer, Siemens, Whitworth, Martin, Vickers, Bell, Bauschinger, Styffe, and many others within the period comprised in this retrospect; and our national predilections will perhaps lead us to the opinion that our own country may fairly appropriate a large share of merit for the results achieved.

Another of the uses of steel to which attention may be given is that of the production of cannon of large size.

Efforts had been made by some of our enterprising workers in metal to produce large guns of solid wrought iron; but the processes of heating and hammering were attended with so much difficulty that the attempt was given up. Here again Krupp stepped in, and succeeded, thirty-two years ago, in manufacturing cannon of cast steel, which unhappily have become ordinary commodities with those nationalities who could afford such expensive weapons. Since that time Krupp has produced about 2,000 guns, the heaviest being, when finished, 72 tons (16 inch).

Sir William Armstrong and Sir Joseph Whitworth soon came into the field with guns of their own invention. The former, by adopting the system of iron coils applied externally to a central cylinder; and the latter, by shrinking cylindrical hoops on to a central cylinder made of cast steel.

In the adaptation of the steel manufacture of the cast or crucible steel period to the production of every object demanded by the march of engineering and mechanical science, I need not mention the names of individuals and firms in this town who have shown themselves equal to the task; but I will venture to say that their success has been such as to raise the town of Sheffield to the very pinnacle of fame as producing steel of any, even the highest quality, demanded in the markets of the world.

I must now turn to a name honored everywhere for the benefits and renown he has brought to his country by his inventions and appliances, during the last twenty-four or twenty-five years, in the manufacture of steel which can be cheaply produced and readily adapted to the requirements of the purchaser. I am sure the audience will in their minds anticipate the record of the name of Bessemer—a name which will be handed down to posterity in connection with the manufacture of steel as long as that manufacture exists.

Another name which will most deservedly figure in the history of the development of the steel manufacture is one, like that of Bessemer, which has been known not only in that development, but in connection with many other discoveries in physical science—I mean that of Siemens, who, like his compeer, has not only invented processes, but has personally carried them out into practical application. An expression let fall by the latter, as President of the Iron and Steel Institute at its meeting last year in Paris, exhibits very strikingly the absence of any other feeling on the part of these two great men save that of the most friendly rivalry.

Speaking of a comparison between the results of steel manufactured by the Bessemer blowing process and the Siemens-Martin open-hearth process, Dr. Siemens said, "He did not see how the result could be the same. It might be better in the Bessemer process than in the open hearth for aught he knew, but it could not be the same;" and it seems to augur well for the advancement of science in our day that so little of a contrary spirit is exhibited in the discussions which ensue from time to time upon any improved process, either chemical or mechanical, having for its object the production of a better material at a lower first cost. The name of Robert Mushet may very properly be introduced as one of our early inventors of the improved processes for the manufacture of steel, and it is gratifying to find that other countries besides England have learned to appreciate the results obtained by him during so many years of scientific and experimental research.

It is needless that I should do more in an assembly like that before me than refer, in the simplest terms, to the differences in the processes of manufacture connected with these names.

In that of Bessemer, pig-iron of a selected quality is charged into what is technically called a "converter," a large cast-iron vessel into which air can be blown at considerable velocity by suitable blowing machinery. This goes on until the iron is thoroughly oxidized and the impurities contained in the metal are driven off. When this happens the blowing ceases, and a certain proportion of Spiegeleisen or of ferro-manganese is added to the charge so as to give the required amount of carbon. Blowing recommences, this time only to effect complete mixture of the materials, and then the casting of the ingots take place of a quality corresponding to the metal selected for the mixtures. A mild steel—or, as it has been called, a pure iron—is the resultant, and it is capable of being worked, welded, and hammered very much as in the case of the purest wrought irons; but it possesses generally a much higher tensile resistance and a greater ductility.

In the Siemens-Martin, or open-hearth process, a similar charge of pig-iron of the desired quality—probably hæmatite pig—is put into the bed of a reverberatory furnace of the regenerative system, and the necessary oxidation is produced by adding to the molten mass iron ores, or oxides of iron in proportions ascertained by experience, after which recarbonization is obtained by the addition of ferro-manganese or Spiegeleisen as in the Bessemer process.

These processes have been the great factors in that reduction in the cost price, and therefore in the extension of the use of such objects as steel tires, axles, shafts, rails, etc., to which I have already referred, and which is so striking an instance of the results which our men of science can accomplish by their physical and experimental researches into the means of supplying the wants of our work-a-day world.

I will now draw attention to another product of the steel manufacture which is of immense importance, and which could not have been obtained for ordinary purposes but for the facilities of manufacture arising out of the inventions I have just alluded to—I mean that of steel castings, *i.e.*, castings obtained from the crucible, precisely in the form in which they are to be used in the construction of machinery, just as is the case in ordinary cast iron run from the cupola furnace. This production of castings for engineering purposes is gaining an enormous and rapid development; and when it is considered that in this metal we obtain castings of a strength at least three to four times that of the strongest iron castings, the importance of this experimental discovery can scarcely be over-rated.

Nor must I pass over the application of these processes to the production of boiler plates, bridge girder plates, and ship plates, in which, as a result of the greater tensile resistance of such plates (reaching for ordinary uses a figure of about twenty-eight to thirty-four tons to the square inch), the engineer is not only enabled to lighten his structure, but to expect from it greater durability—an expectation not diminished by its greater capability of resisting corrosion, especially where care is taken to exclude manganese from the mixture of the metals employed.

For specific purposes, and where price is not so much an element of consideration as great tensile or percussive resistance, a more costly mode of manufacture has been adopted by Sir Joseph Whitworth, whose attention was probably drawn to the necessity for obtaining such a metal during the construction of cannon and torpedoes, but which has now been extended to objects of a very varied character. The method of manufacture, which has been in use upwards of ten years, is by casting ingots under very heavy hydraulic pressure, from very carefully selected materials, the result being the production of a metal of enormous tensile resistance, reaching, in some instances, the high figure of 100 tons per square inch, while at the same time the bubbles and air vesicles, which sometimes appear in metal produced in the ordinary methods, are entirely or almost entirely got rid of, and the consequent striations and imperfections of internal structure and external surface disappear.

It is hoped that ere long we shall be able to procure in this way cylindrical boiler plates rolled solid from the ingot, much after the fashion in which weldless steel tires are now obtained, and that the weakening of these plates by the existing necessity for forming horizontal riveted joints may thus be avoided.

It is desirable before closing this, I fear, already somewhat long address, to call attention to the most recent development of steel manufacture as exhibited in the processes of Messrs. Snellus, Gilchrist, and Thomas, by which iron containing a considerable proportion of, say, 1·44 per cent. of phosphorus, may, in the course of its manufacture into either Bessemer or Siemens-Martin steel, have this deleterious matter entirely removed, or reduced to an inconsiderable proportion.

The method of carrying out this operation was exceedingly well described at the recent meeting of the Iron and Steel Institute in London, and it was shown that where such irons were melted in vessels lined with a slag having twenty per cent. of silica and thirty per cent. of lime and magnesia, the phosphorus was gradually and effectually absorbed by this lining, and a steel of good quality, comparatively free from phosphorus and silica, was produced.

The result to the community will naturally be that, as henceforth a much more extended area of our iron fields both at home and abroad will become available for the production of steel, the use of that metal will be still further extended and its price reduced mainly by means of the methodical reseaches of our scientific metallurgists, and entirely independently of those accidental combinations which have in less scientific days led to the adoption of new and improved methods in the production of metals required by the progress of mechanical and economic science.

ETHERSPHERES.

THE Rev. S. Earnshaw, M.A., read a paper before the British Association on "Etherspheres as a *Vera Causa* of Natural Philosophy." The author, assuming an admitted parallelism between the phenomena of light and heat, proceeds by means of three hitherto overlooked propositions in natural philosophy to establish the universal existence of what he denominated etherspheres, the third of his propositions being, "Every atom of matter in the universe is surrounded by an ethersphere of its own."

The following is the system of nature which he found sufficient for his purpose:

1. In nature there are two distinct substances, matter and ether, neither of which has any power to attract or repel the other.

2. Matter consists of atoms which attract each other with forces varying according to the Newtonian law (distance) 2.

3. The atoms of bodies of the same kind are alike in all respects; atoms of bodies of different kinds differ from each other in size, and possibly also in other respects, such as shape, etc.

4. Atoms, whether of matter or of ether, are incapable of experiencing any change of figure or dimensions, and they are all assumed to be of such geometrical forms as cannot fill space.

5. From the phenomena of light it has been inferred that atoms of ether repel each other with a force varying as (distance) 4.

6. Every atom of matter is impervious to ether, and acts on ether in no other way than by pressure of contact.

7. A portion of space filled with matter is necessarily void of ether; and all space void of matter is pervaded by ether.

8. The enormous velocity of light in free space has led to the opinion that very great must be the repulsive power of ether on ether, and it seems to follow from this that an ether atom will experience great difficulty in moving from one part of the ethereal medium to another. Except as waves and currents ether motion will be under great restraints, and especially shall we see this when we also remember the high power of its inverse law of force.

9. In free space light is believed to be transmitted with the same velocity in every direction, and from this we infer that the atoms of ether are all spherical in form.

Defining an ether sphere, the author said all space not filled by matter is pervaded by ether, so that every atom of matter is surrounded by ether, but this is not what is included in the word "ethersphere." If any portion of space be rendered void of ether from any cause whatever, that space has become void of the repulsive forces which were centered within it, and that, consequently, when these forces are taken away, the medium outside the space will draw closer toward that space; and if the space be occupied by an atom of matter, the density of the surrounding ether will be greater than before, and the ether, being in contact with the atom at its surface, will press upon it.

The excess of ether about the vacant space above its original quantity constitutes the ethersphere, and though this gathering together of ether about the space now occupied by the atom is a consequence of the presence of the atom, it is in no way owing to its action on the ethereal medium. Mr. Earnshaw then argued that if every material atom, so must every compound system of atoms, *i.e.*, every material body, whether gaseous, liquid, or solid, have an ethersphere, which not only surrounds the whole body, but also penetrates the interstitial spaces of the body which lie between its atoms. By means of these etherspheres the author believed the phenomena of heat may be satisfactorily accounted for, on the supposition that the ethereal medium is the medium of heat as well as of light.

They were shown to have a remarkable bearing also on the phenomena of magnetism, electricity, and galvanism. He, therefore, concluded that etherspheres constitute a *vera causa*, the existence of which in nature is as certain as is that of the ethereal medium itself, about which no philosopher expresses doubt in the present day.

Mr. J. E. H. Gordon observed that if the Rev. Mr. Earnshaw could establish his theory, it would be a great help to all persons at present engaged in the study of electricity.

The author remarked that he intended to publish a portion of his paper, but the working out of his theory must be left to some younger person.

Dr. Lodge inquired if Mr. Earnshaw considered that ether has the property of inertia?

Mr. Earnshaw replied in the negative. He did not require that it should possess that property.

Prof. Everitt asked what was the particular experimental law relating to gases which followed from his theory?

Mr. Earnshaw replied that, speaking roughly, one was that there was a pressure, whatever might be the nature of the gas, and, of course, the pressure depended upon the elasticity of the gas. The interpenetration of gases was dependent upon the fact that the sizes of the particles of the two gases differed. That caused their etherspheres to vary in size, and thus enabled one gas to penetrate another.

DECOMPOSITION OF CHLORINE.

CHEMISTS and physicians now almost universally entertain the theory that all bodies, whether gaseous, liquid, or solid, consist of extremely minute particles or molecules. Each molecule consists of a definite quantity of matter, which is exactly the same for all molecules of the same substance. The molecules of most substances, however, are themselves compounds, and consist of atoms, which, as the name implies, are held to be indivisible; but whereas the molecules of what are ordinarily termed compound bodies contain dissimilar atoms, the molecules of the so-called elements are supposed to be composed of similar atoms. For example, in a molecule of water two atoms of hydrogen are combined with a single atom of oxygen, but a molecule of hydrogen consists of two atoms of hydrogen and a molecule of oxygen of two atoms of oxygen. The molecules of the elements do not always contain two atoms, however; the molecule of mercury, for example, consisting of a single atom, and that of phosphorus of no less than four. To determine the number of atoms which compose the molecule of any given substance is one of the most important operations the chemist is called upon to perform. The method in use is based on the theory that equal volumes of all substances in the state of gas, if at the same temperature and pressure, contain equal numbers of molecules; so that, whatever the actual number of molecules in a given volume of gas, if the weight of the given volume of gas be ascertained and compared with the weight of the same volume of another gas under precisely the same conditions of temperature and pressure, numbers are obtained which represent the relative weights of the molecules of the two gases in question. These numbers are always the same whatever the temperature and pressure at which the comparison is made, provided that no decomposition of the molecules of either of the substances occurs. The determination in question is technically known as the determination of the gaseous or vapor density of a substance.

Either air or hydrogen is taken as the standard of comparison, the latter being the more convenient, as it is universally adopted as the standard to which the atomic weights of the elements are referred, the atomic weight of an element being a number which represents the weight of its atom, supposing that of the hydrogen atom to be 1. Using the hydrogen standard, if we say, for example, that the density of oxygen is 16, we mean simply that a given volume of oxygen weighs 16 times as much as an equal volume of hydrogen.

Certain considerations which need not here be entered into lead us to suppose that the molecule of hydrogen consists, as we have said, of two atoms, so that if the weight of the hydrogen atom be unity, the weight of its molecule is twice as great; in other words, 1 being the atomic weight of hydrogen, 2 is the molecular weight of hydrogen. Hence if we determine the density of any substance in the state of gas relatively to that of hydrogen, we have merely to double the number representing its density in order to obtain the weight of its molecule as compared with that of the hydrogen molecule; and dividing the number representing the molecular weight of an element by its atomic weight, we obtain a quotient which expresses the number of atoms in the molecule of the particular element. Thus, the density of ordinary oxygen being 16, its molecular weight is twice 16, or 32; and, therefore, since 16 is the atomic weight of oxygen, the molecule of oxygen consists of two atoms. But if we take oxygen in the state of ozone, we find that its density is higher than that of ordinary oxygen—viz., 24; the ozone molecule is therefore twice 24 times as heavy as the hydrogen molecule; and since the quotient of 48 divided by 16 is 3, we conclude that it consists of three atoms, the molecule of ordinary oxygen consisting of only two atoms. When moderately heated, ozone is entirely converted into ordinary oxygen, and the density diminishes from 24 to 16, two-thirds of its value.

Some few months ago, Professor Victor Meyer, of Zurich, devised a new, most ingenious and expeditious method of determining gaseous or vapor densities, and as it enabled him to work at high temperatures with far greater facility than any of the methods previously known, he was led, in conjunction with Herr C. Meyer, to make experiments with a variety of substances, and among others with the "element" chlorine. The results they obtained at temperatures not much exceeding 600° Centigrade were in accordance with previous observations made at lower temperatures, being such as to indicate that the molecules of chlorine, like those of hydrogen and oxygen, each consisted of two atoms. But on extending their observations to higher temperatures they noticed that the density diminished until at about 1,200° it was only two-thirds as great as at 600° and below. No further alteration, however, occurred, on heating to nearly 1,600°. The change in density being precisely similar to that observed on heating ozone, it would appear possible that a similar kind of alteration in the composition of the molecules of chlorine had occurred—that is to say, that the chlorine molecules are composed of the same kind of atoms, but in different numbers at low and at high temperatures. There are, however, a variety of considerations opposed to such a

conclusion, and it would appear more probable that chlorine is not an element, as has hitherto been supposed, but a compound of dissimilar atoms. It is stated that the Messrs. Meyer have actually succeeded in proving this, and that oxygen is one of the components of chlorine; but no particulars of their experiments have as yet come to hand. Such a discovery would be the first approach to a substantiation of Mr. Lockyer's views of the non-elementary character of the so-called elements to which we had occasion to refer at length some few months ago, and which were chiefly based on observations of the spectra of the metallic elements taken in conjunction with solar and stellar phenomena.

MATERIALISM AND ITS LESSONS.

By Dr. Henry Maudsley.

It is well known that from an early period of speculative thought two doctrines have been held with regard to the sort of connection which exists between a man's mind and his body. On the one hand, there are those who maintain that mind is an outcome and function of matter in a certain state of organization, coming with it, growing with it, decaying with it, inseparable from it: they are the so-called materialists. On the other hand, there are those who hold that mind is an independent spiritual essence which has entered into the body as its dwelling-place for a time, which makes use of it as its mortal instrument, and which will take on its independent life when the body, worn out by the operation of natural decay, returns to the earth of which it is made: they are the spiritualists.

Without entering into a discussion as to which is the true doctrine, it will be sufficient in this article to accept and proceed from the basis of the generally admitted fact, that all the manifestations of mind which we have to do with in this world are connected with organization, dependent upon it, whether as cause or instrument; that they are never met with apart from it, any more than electricity or any other natural force is met with apart from matter, and that higher organization must go along with higher mental function. What is the state of things in another world—whether the disembodied or celestially embodied spirits of the countless myriads of the human race that have come and gone through countless ages are now living higher lives—I do not venture to inquire. One hope and one certitude in the matter every one may be allowed to have and to express—the hope that, if they are living now, it is a higher life than they lived upon earth; the certitude that, if they are living the higher life, most of them must have had a vast deal to unlearn.

Many persons who readily admit in general terms the dependence of mental function on cerebral structure are inclined, when brought to the particular test, to make an exception in favor of the moral feeling or conscience. They are content to rest in the uncertain position which satisfied Dr. Abercrombie, the distinguished author of the well known "Inquiry Concerning the Intellectual Powers," who, having pointed out plainly the dependence of mental function on organization, and, as a matter of fact which cannot be denied, that there are individuals in whom every correct feeling in regard to moral relations is obliterated, while the judgment is unimpaired in all other relations, stops there, without attempting to prosecute inquiry into the cause of the remarkable fact which he justly emphasizes. "That this power," he says, "should so completely lose its sway, while reason remains unimpaired, is a point in the moral constitution of man which it does not belong to the physician to investigate. The fact is unquestionable; the solution is to be sought in the records of eternal truth." And with this lame and somewhat melancholy conclusion he leaves his readers impotent before a problem which is not only of deep scientific interest, but of momentous practical importance. The observation which makes plain the fact does not, however, leave us entirely without information concerning the cause of it, when we pursue it faithfully, since it reveals as distinct a dependence of moral faculty upon organization as of any other faculty.

MENTAL EFFECTS OF INJURY TO THE BRAIN.

Many instructive examples of the pervading mental effects of physical injury of the brain might be quoted, but two or three, recently recorded, will suffice.

An American medical man was called one day to see a youth, aged eighteen, who had been struck down insensible by the kick of a horse. There was a depressed fracture of the skull a little above the left temple. The skull was trephined, and the loose fragments of bone that pressed upon the brain were removed, whereupon the patient came to his senses. The doctor thought it a good opportunity to make an experiment, as there was a hole in the skull through which he could easily make pressure upon the brain. He asked the boy a question, and, before there was time to answer it, he pressed firmly with his finger upon the exposed brain. As long as the pressure was kept up the boy was mute, but the instant it was removed he made a reply, never suspecting that he had not answered at once. The experiment was repeated several times, with precisely the same result, the boy's thoughts being stopped and started again on each occasion as easily and certainly as the engineer stops and starts his locomotive.

On another occasion the same doctor was called to see a groom who had been kicked on the head by a mare called Dolly, and whom he found quite insensible. There was a fracture of the skull, with depression of bone at the upper part of the forehead. As soon as the portion of bone which was pressing upon the brain was removed, the patient called out with great energy, "Whoa, Dolly!" and then stared about him in blank amazement, asking: "Where is the mare? Where am I?" Three hours had passed since the accident, during which the words which he was just going to utter when it happened had remained locked up, as they might have been locked up in the phonograph, to be let go the moment the obstructing pressure was removed. The patient did not remember, when he came to himself, that the mare had kicked him; the last thing before he was insensible which he did remember was, that she wheeled her heels round and laid back her ears viciously.

Cases of this kind show how entirely dependent every function of mind is upon a sound state of the mechanism of the brain. Just as we can, by pressing firmly upon the sensory nerve of the arm, prevent an impression made upon the finger being carried to the brain and felt there, so by pressing upon the brain we can as certainly stop a thought or a volition. In both cases a good recovery presently followed the removal of the pressure upon the brain; but it would be of no little medical interest to have the after histories of the persons, since it happens sometimes after a serious injury to the head, that, despite an immediate recovery, slow, degenerate changes are set up in the brain months or years afterward, which go on to cause a gradual weakening, and perhaps eventual destruction, of mind.

THE MORAL CHARACTER FIRST IMPAIRED.

Now the instructive matter in this case is, that the moral character is usually impaired first, and sometimes is completely perverted, without a corresponding deterioration of the understanding; the person is a thoroughly changed character for the worse. The injury has produced disorder in the most delicate part of the mental organization, that which is separated from actual contact with the skull only by the thin investing membranes of the brain, and, once damaged, it is seldom that it is ever restored completely to its former state of soundness. However, happy recoveries are now and then made from mental derangement caused by physical injury to the brain.

Some years ago a miner was sent to the Ayrshire District Asylum, who, four years before, had been struck to the ground insensible by a mass of falling coal, which fractured his skull. He lay unconscious for four days after the accident, then came gradually to himself, and was able in four weeks to resume his work in the pit. But his wife noticed a steadily increasing change for the worse in his character and habits; whereas he had formerly been cheerful, sociable, and good-natured, always kind and affectionate to her and his children, he now became irritable, moody, surly, suspicious, shunning the company of his fellow-workmen, and impatient with her and the children. This bad state increased; he was often excited, used threats of violence to his wife and others, finally became quite maniacal, attempted to kill them, had a succession of epileptic fits, and was sent to the asylum as a dangerous lunatic. There he showed himself extremely suspicious and surly, entertained a fixed delusion that he was the victim of a conspiracy on the part of his wife and others, and displayed bitter and resentful feelings.

At the place where the skull had been fractured there was a well marked depression of bone, and the depressed portion was eventually removed by the trephine. From that time an improvement took place in his disposition, his old self coming gradually back; he became cheerful again, active and obliging, regained and displayed all his former affection for his wife and children, and was at last discharged recovered.

No plainer example could be wished to show the direct connection of cause and effect—the great deterioration of moral character produced by the physical injury of the supreme nerve centers of the brain: when the cause was taken away the effect went also.

HOW DISEASE INJURES THE MORAL CHARACTER.

Going a step further, let me point out that disease will sometimes do as plain and positive damage to moral character as any which direct injury of the brain will do. A fever has sometimes deranged it as deeply as a blow on the head; a child's conscience has been clean effaced by a succession of epileptic convulsions, just as the memory is sometimes effaced; and those who see much of epilepsy know well the extreme but passing moral transformations that occur in connection with its seizures. The person may be as unlike himself as possible when he is threatened with a fit; although naturally cheerful, good-tempered, sociable, and obliging, he becomes irritable, surly, and morose, very suspicious, takes offense at the most innocent remark or act, and is apt to resent imaginary offenses with great violence. The change might be compared well with that which happens when a clear and cloudless sky is overcast suddenly with dark and threatening thunder-clouds; and just as the darkly clouded sky is cleared by the thunder-storm which it portends, so the gloomy moral perturbation is discharged, and the mental atmosphere cleared by an epileptic fit or a succession of such fits.

In a few remarkable cases, however, the patient does not come to himself immediately after the fit, but is left by it in a peculiar state of quasi-somnambulism, during which he acts like an automaton, doing strange, absurd, and sometimes even criminal things, without knowing apparently at the time what he is doing, and certainly without remembering in the least what he has done when he comes to himself. Of excellent moral character habitually, he may turn thief in one of these states, or perpetrate some other criminal offense by which he gets himself into trouble with the police.

There are other diseases which, in like manner, play havoc with moral feeling. Almost every sort of mental derangement begins with a moral alienation, slight perhaps at the outset, but soon so great that a prudent, temperate, chaste, and truthful person shall be changed to exactly the opposite of what he was. This alienation of character continues throughout the course of the disease, and it is frequently found to last for a while after all disorder of intelligence has gone. Indeed, the experienced physician never feels confident that the recovery is stable and sure, until the person is restored to his natural sentiments and affections. Thus it appears that when mind undergoes decadence, the moral feeling is the first to suffer; the highest acquisition of mental evolution, it is the first to witness to mental degeneracy.

MENTAL EFFECTS OF PARALYSIS.

One form of mental disease, known as general paralysis, is usually accompanied with a singularly complete paralysis of the moral sense from the outset, and a not uncommon feature of it, very striking in some cases, is a persistent tendency to steal, the person stealing in a weak minded manner what he has no particular need of, and makes no use of when he has stolen it. The victim of this fatal disease is frequently sent to prison and treated as a common criminal in the first instance, notwithstanding that a medical man who knows his business might be able to say with entire certitude that the supposed criminal was suffering from organic disease of the brain, which had destroyed moral sense at the outset, which would go on to destroy all the other faculties of his mind in succession, and which in the end would destroy life itself. There is no question in such case of moral guilt; it is not sin, but disease that we are confronted with; and after the victim's death we find the plainest evidence of disease of brain, which has gone along with the decay of mind. Had the holiest saint in the calendar been afflicted as he was, he could not have helped doing as he did.

EFFECTS OF ALCOHOL AND OPIUM ON THE MORAL SENSE.

I need not dwell any longer upon the morality-sapping effects of particular diseases, but shall simply call to mind the profound deterioration of moral sense and will which is produced by the long continued and excessive use of alcohol and opium. There is nowhere a more miserable specimen of degradation of moral feeling and of impotence of will than the debauchee who has made himself the abject slave of either of these pernicious excesses. Insensible to the interests of his family, to his personal responsibilities, to the obligations of duty, he is utterly untruthful and untrustworthy, and in the worst end there is not a meanness of pretense or of conduct that he will not descend to, not a lie he will not tell, in order to gain the means to gratify his overruling craving. It is not merely that passion is strengthened and will weakened by indulgence as a moral effect, but the alcohol or opium which is absorbed into his blood is carried by it to the brain and acts injuriously upon its tissues: the chemist will, indeed, extract alcohol from the besotted brain of the worst drunkard, as he will detect morphia in the secretions of a person who is taking large doses of morphia.

Seldom, therefore, is it of the least use to preach reformation to these people, until they have been restrained forcibly from their besetting indulgence for a long enough period to allow the brain to get rid of the poison, and its tissues to regain a healthier tone. Too often it is of little use then; the tissues have been damaged beyond the possibility of complete restoration. Moreover, observation has shown that the drink craving is oftentimes hereditary, so that a taste for the poison is ingrained in the tissues, and is quickly kindled by gratification into uncontrollable desire.

DEPENDENCE OF MIND AND SPIRIT ON ORGANIZATION.

Thus far it appears, then, that moral feeling may be impaired or destroyed by direct injury of the brain, by the disorganizing action of disease, and by the chemical action of certain substances which, when taken in excess, are poisons to the nervous system. When we look sincerely at the facts, we cannot help perceiving that it is just as closely dependent upon organization as is the meanest function of mind; that there is not an argument to prove the so-called materialism of one part of mind which does not apply with equal force to the whole mind. Seeing that we know no more essentially what matter is than what mind is, being unable in either case to go beyond the phenomena of which we have experience, it is of interest to ask why the spiritualist considers his theory to be of so much higher an intellectual and moral order than materialism, and looks down with undisguised pity and contempt on the latter as inferior, degrading, and even dangerous; why the materialist should be deemed guilty, not of intellectual error only, but of something like moral guilt?

His philosophy has been lately denounced as a "philosophy of dirt." An eminent prelate of the English Church, in an outburst of moral indignation, once described him as possibly "the most odious and ridiculous being in all the multiform creation;" and a recent writer in a French philosophical journal uses still stronger language of abhorrence: "I abhor them," he says, "with all the force of my soul. . . . I detest and abominate them from the bottom of my heart, and I feel an invincible repugnance and horror when they dare to reduce psychology and ethics to their bestial physiology—that is, in short, to make of man a brute, of the brute a plant, of the plant a machine. . . . This school is a living and crying negation of humanity." The question is, what there is in materialism to warrant the sincere feeling and earnest expression of so great a horror of it. Is the abhorrence well founded, or is it perhaps that the doctrine is hated, as the individual oftentimes is, because misunderstood?

THE DOCTRINE OF A SEPARATE SPIRIT.

This must certainly be allowed to be a fair inquiry by those who reflect that no less eminent a person and good a Christian than Milton was a decided materialist. Several scattered passages in "Paradise Lost" plainly betray his opinions, but it is not necessary to lay any stress upon them, because in his "Treatise on Christian Doctrine" he sets them forth in the most plain and uncompromising way, and supports them with an elaborate detail of argument. He is particularly earnest to prove that the common doctrine that the spirit of man should be separate from the body, so as to have a perfect and intelligent existence independently of it, is nowhere said in Scripture, and is at variance both with nature and reason, and he declares that "man is a living being, intrinsically and properly one and individual, not compound and separable, not, according to the common opinion, made up and framed of two distinct parts, as of soul and body."

Another illustrious instance of a good Christian who for a great part of his life avowed his belief that "the nature of man is simple and uniform, and that the thinking power and faculties are the result of a certain organization of matter," was the eloquent preacher and writer, Robert Hall. It is true that he abandoned this opinion at a later period of his life; indeed, his biographer tells us with much satisfaction that "he buried materialism in his father's grave;" and a theological professor in an American college has in a recent article exultantly claimed this fact as triumphant proof that the materialist's "gloomy and unnatural creed" cannot stand before such a sad feeling as grief at a father's death. One may be excused perhaps for not seeing quite so clearly as these gentlemen the soundness of the logic of the connection. On the whole, logic is usually sounder and stronger when it is not under the pressure of great feeling.

THE HOPE OF IMMORTALITY.

The truth is, that a great many people have the deeply rooted feeling that materialism is destructive of the hope of immortality, and dread and detest it for that reason. When they watch the body decay and die, considering furthermore that after its death it is surely resolved into the simple elements from which all matter is formed, and know that these released elements go in turn to build up other bodies, so that the material is used over and over again, being compounded and decompounded incessantly in the long stream of life, they cannot realize the possibility of a resurrection of the individual body. They cannot conceive how matter, which has thus been used over and over again, can remake so many distinct bodies, and they think that to uphold a bodily resurrection is to give up practically the doctrine of a future life.

It is a natural but not a necessary conclusion, as the examples of Milton and Robert Hall prove, since they, though materialists, were devout believers in a resurrection of the dead. Moreover, there are many vehement antagonists of materialism who readily admit that it is not inconsistent with the belief in a life after death. Indeed they could not well do otherwise when they recollect what the Apostle Paul said in his very energetic way, addressing the objector to a bodily resurrection as "Thou fool!" and what happened to the rich man who died and was buried; for it is told of him that "in hell he lifted up his eyes, and cried and said, Father Abraham, have mercy on me, and send Lazarus, that he may dip the tip of his finger in water, and cool my tongue; for I am tormented in this flame."

Now, if he had eyes to lift up and a tongue to be

cooled, it is plain that he had a body of some kind in hell; and if Lazarus, who was in another place, had a finger to dip in water, he also must have had a body of some kind there.

LESSONS OF HUMILITY AND REVERENCE.

Leaving this matter, however, without attempting to explain the mystery of the body celestial, I go on to mention a second reason why materialism is considered to be bad doctrine. It is this: that with the rise and growth of Christianity there came in the fashion of looking down on the body with contempt as the vile and despicable part of man, the seat of those fleshly lusts which warred against the higher aspirations of the soul. It was held to be the favorite province of the devil, who, having intrenched himself there, lay in wait to entice or to betray to sin; the wiles of Satan and the lusts of the flesh were spoken of in the same breath, as in the service of the English Church prayer is made for "whatsoever has been decayed by the fraud and malice of the devil, or by his own carnal will and frailness;" and all men are taught to look forward to the time when "he shall change this vile body and make it like unto his glorious body." It was the extreme but logical outcome of this manner of despising the body to subject it to all the penances, and to treat it with all the rigor, of the most rigid asceticism—to neglect it, to starve it, to scourge it, to mortify it in every possible way.

One holy ascetic would never wash himself, or cut his toenails, or wipe his nose; another suffered maggots to burrow unchecked into the neglected ulcers of his emaciated body; others, like St. Francis, stripped themselves naked and appeared in public without clothes. St. Macarius threw away his clothes and remained naked for six months in a marsh, exposed to the bite of every insect; St. Simeon Stylites spent thirty years on the top of a column which had been gradually raised to a height of sixty feet, spending a great part of his time in bending his meager body successively with his head toward his feet, and so industriously that a curious spectator, after counting twelve hundred and forty-four repetitions, desisted counting from weariness. And for these things—these insanities of conduct, may we not call them?—they were accounted most holy, and received the honors of saintship. Contrast this unworthy view of the body with that which the ancient Greeks took of it. They found no other object in nature which satisfied so well their sense of proportion and manly strength, of attractive grace and beauty; and their reproductions of it in marble we preserve now as priceless treasures of art, albeit we still babble the despicable doctrine of contempt of it. The more strange, since it is a matter of sober scientific truth that the human body is the highest and most wonderful work in nature, the last and best achievement of her creative skill; it is a most complex and admirably constructed organism, "fearfully and wonderfully made," which contains, as it were in a microcosm, all the ingenuity and harmony and beauty of the macrocosm. And it is this supreme product of evolution that fanatics have gained the honor of saintship by disfiguring and torturing!

These, then, are two great reasons of the repugnance which is felt to materialism, namely, the notion that it is destructive of the hope of a resurrection, and the contempt of the body which has been inculcated as a religious duty. And yet on these very points materialism seems fitted to teach the spiritualist lessons of humility and reverence, for it teaches him, in the first place, not to despise and call unclean the last and best work of his Creator's hand; and, secondly, not impiously to circumscribe supernatural power by the narrow limits of his understanding, but to bethink himself that it were just as easy in the beginning, or now, or at any time, for the omnipotent Creator of matter and its properties to make it think as to make mind think.

Passing from these incidental lessons of humility and reverence, I go on now to show that materialism has its moral lessons, and that these, rightly apprehended, are not at all of a low intellectual and moral order, but, on the contrary, in some respects more elevating than the moral lessons of spiritualism. I shall content myself with two or three of these lessons, not because there are not more of them, but because they will be enough to occupy the space at my disposal.

BRAIN DIFFERENCES AND VALUES.

It is a pretty well accepted scientific doctrine that our far-distant prehistoric ancestors were a very much lower order of beings than we are, even if they did not inherit directly from the monkey; that they were very much like, in conformation, habits, intelligence, and moral feeling, the lowest existing savages; and that we have risen to our present level of being by a slow process of evolution which has been going on gradually through untold generations. Whether or not "through the ages one increasing purpose runs," as the poet has it, it is certainly true that "the thoughts of men are widened with the process of the suns." Now, when we examine the brain of the lowest savage, whom we need not be too proud to look upon as our ancestor in the flesh—say a native Australian or a Bushman—we find it to be considerably smaller than an ordinary European brain; its convolutions, which are the highest nerve centers of mind, are decidedly fewer in number, more simple in character, and more symmetrical in arrangement. These are marks of inferiority, for in those things in which it differs from the ordinary European brain it gets nearer in structure to the still much inferior brain of the monkey; it represents, we may say, a stage of development in the long distance which has been traversed between the two. A comparison of the relative brain weights will give a rude notion of the differences: the brain weight of an average European male is forty-nine ounces; that of a Bushman is, I believe, about thirty-three ounces; and that of a negro, who comes between them in brain size as in intelligence, is forty-four ounces. The small brain weight of the Bushman is indeed equaled among civilized nations by that of a small headed or so called microcephalic idiot. There can be no doubt, then, of a great difference of development between the highest and the lowest existing human brain.

There can be no doubt, furthermore, that the gross differences which there are between the size and development of the brain of a low savage and of an average European, go along with as great differences of intellectual and moral capacities—that lower mental function answers to lower cerebral structure. It is a well known fact that many savages cannot count beyond five, and that they have no words in their vocabulary for the higher qualities of human nature, such as virtue, justice, humanity, and their opposites, vice, injustice, and cruelty, or for the more abstract ideas. The native Australian, for example, who is in this case, having no words for justice, love, mercy, and the like, would not in the least know what remorse meant; if any one showed it in his presence, he would think probably that he had got a bad headache. He has no words to express the higher sentiments and thoughts, because he has never felt and thought them, and has never had, therefore, the need to express them; he has not in his inferior brain the nervous substrata which should minister to such sentiments and thoughts, and can not have them in his present state of social evolution, any more than he could make a particular movement of his body if the proper muscles were wanting. Nor could any amount of training in the world, we may be sure, ever make him equal in this respect to the average European, any more than it could add substance to the brain of a small headed idiot and raise it to the ordinary level.

Were any one, indeed, to make the experiment of taking the young child of an Australian savage and of bringing it up side by side with an average European child, taking great pains to give them exactly the same education in every respect, he would certainly have widely different results in the end; in the one case he would have to do with a well organized instrument, ready to give out good intellectual notes and a fine harmony of moral feeling when properly handled; in the other case, an imperfectly organized instrument, from which it would be out of the power of the most patient and skillful touch to elicit more than a few feeble intellectual notes and a very rude and primitive sort of moral feeling—a little better feeling, certainly, than that of its fathers, but still most primitive; for many savages regard as virtues most of the big vices and crimes, such as theft, rape, murder, at any rate when they are practiced at the expense of neighboring tribes.

Their moral feeling, such as it is, is extremely circumscribed, being limited in application to the tribe. In Europe we have happily got further than that, since we are not, as savages are and our forefathers probably were, divided into a multitude of tribes eager to injure and even extirpate one another from motives of tribal patriotism; but mankind seems to be far off the goal of its high calling so long as, divided into jealous and hostile nations, it suffers national divisions to limit the application of moral feeling, counts it a high virtue to violate it under the profaned name of patriotism, and uses the words "humanitarianism" and "cosmopolitanism" as crushing names of reproach. There is plainly room yet for a wider expansion of moral feeling.

THE TEACHINGS OF SCIENCE CONCERNING THE GROWTH OF MORAL CHARACTER.

Now, what do the discoveries of science warrant us to conclude respecting the larger and more complex brain of the civilized man and its higher capacities of thought and feeling? They teach us this: that it has reached its higher level not by any sudden and big creative act, nor by a succession of small creative acts, but by the slow and gradual operation of processes of natural evolution going on through countless ages. Each new insight into natural phenomena on the part of man, each act of wiser doing founded on truer insight, each bettered feeling which has been developed from wiser conduct, has tended to determine by degrees a corresponding structural change of the brain, which has been transmitted as an innate endowment to succeeding generations, just as the acquired habit of a parent animal becomes sometimes the instinct of its offspring; and the accumulated results of these slow and minute gains, transmitted by hereditary action, have culminated in the higher cerebral organization, in which they are now, as it were, capitalized.

Thus the added structure embodies in itself the superior intellectual and moral capacities of abstract reasoning and moral feeling which have been the slow acquisitions of the ages, and it gives them out again in its functions when it discharges its functions rightly. If we were to have a person born in this country with a brain of no higher development than that of the low savage—destitute, that is, of the higher nervous substrata of thought and feeling—if, in fact, our far remote prehistoric ancestors were to come to life among us now—we should have more or less of an imbecile, who could not compete on equal terms with other persons, but must perish, unless charitably cared for, just as the native Australian perishes when he comes into contact and competition with the white man. The only way in which the native Australian could be raised to the level of civilized feeling and thought would be by cultivation continued through many generations—by a process of evolution similar to that which lies back between our savage ancestors and us.

CAUSES OF FAMILY DEVELOPMENT AND DEGENERACY.

That is one aspect of the operation of natural law in human events—the operation of the law of heredity in development, in carrying mankind forward, that is, to a higher level of being. It teaches us plainly enough that the highest qualities of mind bear witness to the reign of law in nature as certainly as do the lowest properties of matter, and that if we are to go on progressing in time to come, it must be by observation of, and obedience to, the laws of development. But there is another vastly important aspect of the law of heredity, which it concerns us to bear sincerely in mind—its operation in working out human degeneracy, in carrying mankind downward, that is, to a lower level of being.

It is certain that man may degenerate as well as develop; that he has been doing so both as nation and individual ever since we have records of his doings on earth. There is a broad and easy way of dissolution, national, social, or individual, which is the opposite of the steep and narrow way of evolution. Now, what it behooves us to realize distinctly is, that there is not anything more miraculous about the degeneracy and extinction of a nation or of a family than there is about its rise and development; that both are the work of natural law. A nation does not sink into decadence, I presume, so long as it keeps fresh those virtues of character through which it became great among nations; it is when it suffers them to be eaten away by luxury, corruption, and other enervating vices, that it undergoes that degeneration of character which prepares and makes easy its overthrow. In like manner a family, reckless of the laws of physical and moral hygiene, may go through a process of degeneracy until it becomes extinct. It was no mere dream of prophetic frenzy that when the fathers have eaten sour grapes the children's teeth are set on edge, nor was it a meaningless menace that the sins of the fathers shall be visited upon the children unto the third and fourth generations; it was an actual insight into the natural law by which degeneracy increases through generations—by which one generation reaps the wrong which its fathers have sown, as its children in turn will reap the wrong which it has sown. What we call insanity or mental derangement is truly, in most cases, a form of human degeneracy, a phase in the working out of it; and, if we were to suffer this degeneracy to take its course unchecked through generations, the natural termination would be sterile idiocy and extinction of the family. A curious despot would find it impossible, were he to make the experiment, to breed and propagate a race of insane people; nature, unwilling to continue a morbid variety of the human kind, would bring his experiment to an end by the production of sterile idiocy. If man will but make himself the subject of serious scientific study, he shall find that this working out of degeneracy through generations affords him a rational explanation of most of those evil impulses of the heart which he has been content to attribute to the wiles and instigations of the devil; that the evil spirit which has taken possession of the wicked man is often the legacy of parental or ancestral error, misfortune, or wrong doing. Let me illustrate by an example the nature and bearing of this scientific study.

HEREDITARY ANTECEDENTS.

I will take for this purpose a case which every physician who has had much experience must have been asked some time or other to consider and advise about: a quite young child, which is causing its parents alarm and distress by the precocious display of vicious desires and tendencies of all sorts, that are quite out of keeping with its tender years, and by the utter failure of either precept, or example, or punishment to imbue it with good feeling and with the desire to do right. It may not be notably deficient in intelligence; on the contrary, it may be capable of learning quickly when it likes, and extremely cunning in lying, in stealing, in gratifying other perverse inclinations; and it cannot be said not to know right from wrong, since it invariably eschews the right and chooses the wrong, showing an amazing acuteness in escaping detection and the punishment which follows detection. It is, in truth, congenitally conscienceless, by nature destitute of moral sense and actively imbued with an immoral sense. Now, this unfortunate creature is of so tender an age that the theory of satanic agency is not thought to offer an adequate explanation of its evil impulses; in the end everybody who has to do with it feels that it is not responsible for its vicious conduct, perceives that punishment does not and cannot in the least reform it, and is persuaded that there is some native defect of mind which renders it a proper case for medical advice. Where, then, is the fault that a human being is born into the world who will go wrong, nay, who must go wrong, in virtue of a bad organization? The fault lies somewhere in its hereditary antecedents. We can seldom find the exact cause and trace definitely the mode of its operation—the study is much too complex and difficult for such exactness at present—but we shall not fail to discover the broad fact of the frequency of insanity or other mental degeneracy in the direct line of the child's inheritance. The experienced physician seldom feels any doubt of that when he meets with a case of the kind. It is indeed most certain that men are not bred well or ill by accident any more than the animals are; but, while most persons are ready to acknowledge this fact in a general way, very few pursue the admission to its exact and rigorous consequences, and fewer still suffer it to influence their conduct.

It may be set down, then, as a fact of observation that mental degeneracy in one generation is sometimes the evident cause of an innate deficiency or absence of moral sense in the next generation. The child bears the burden of its ancestral infirmities or wrong-doings. Here, then, and in this relation, may be noted the instructive fact that just as moral feeling was the first function to be affected at the beginning of mental derangement in the individual, so now the defect or absence of it is seen to mark the way of degeneracy through generations. It was the lastest acquisition of mental evolution; it is the first to go in mental dissolution.

HOW ABSENCE OF MORAL FEELING PRODUCES MENTAL DERANGEMENT.

A second fact of observation may be set down as worthy of consideration, if not of immediate acceptation, namely, that an absence of moral feeling in one generation, as shown by a mean, selfish, and persistent disregard of moral action in the conduct of life, may be the cause of mental derangement in the next generation. In fact, a person may succeed in manufacturing insanity in his progeny by a persistent disuse of moral feeling, and a persistent exercise throughout his life, of those selfish, mean, and anti-social tendencies which are a negation of the highest moral relations of mankind. He does not ever exercise the nervous substrata which minister to moral functions, wherefore they undergo atrophy in him, and he runs the risk of transmitting them to his progeny in so imperfect a state that they are incapable of full development of function in them; just as the instinct of the animal which is not exercised for many generations on account of changed conditions of life, becomes less distinct by degrees and in the end, perhaps, extinct. People are apt to talk as if they believed that insanity might be got rid of were only sufficient care taken to prevent its direct propagation by the marriages of those who had suffered from it or were likely to do so. A vain imagination assuredly! Were all the insanity in the world at the present time clean swept away to-morrow, men would breed it afresh before to-morrow's to-morrow by their errors, their excesses, their wrong-doings of all sorts. Rightly, then, may the scientific inquirer echo the words of the Preacher, that however prosperous a man may have seemed in his life, judge him not blessed before his death; for he shall be known in his children: they shall not have the confidence of their good descent. In sober truth, the lessons of morality which were proclaimed by the prophets of old, as indispensable to the stability and well-being of families and nations, were not mere visions of vague fancy; founded upon actual observation and intuition of the laws of nature working in human events, they were insights into the eternal truths of human evolution.

OBEDIENCE TO THE HIGHER LAWS IMPERATIVELY REQUIRED.

Whether, then, man goes upward or downward, undergoes development or degeneration, we have equally to do with matters of stern law. Provision has been made for both ways; it has been left to him to find out and determine which way he shall take. And it is plain that he must find the right path of evolution, and avoid the wrong path of degeneracy, by observation and experience, pursuing the same method of positive inquiry which has served him so well in the different sciences. Being pre-eminently and essentially a social being, each one the member of one body—the unit, that is, in the social organism—the laws which he has to observe and obey are not the physical laws of nature only, but also those higher laws which govern the relations of individuals in the social state. If he make his observations sincerely and adequately in this way, he cannot fail to perceive that the laws of morality were not really miraculous revelations from heaven any more than was the discovery of the law of gravitation, but that they were essential condi-

tions of social evolution, and were learned practically by the stern lessons of experience. He has learned his duty to his neighbor as he has learned his duty to nature; it is implicit in the constitution of a complex society of men dwelling together in peace and unity, and has been revealed explicitly by the intuition of a few extraordinary men of sublime moral genius.

As it is not a true, it cannot be a useful, notion to foster, that morality was the special gift to man, and is the special property of any theological system, and that its vitality is bound up essentially with the life of any such creed. The golden rule of morals itself—"Do unto others as ye would have others do unto you"—was perceived and proclaimed long before it received its highest Christian expression.* It is not, indeed, religious creed which has invented and been the basis of morality, but morality which has been the bulwark of religions. And as a matter of fact it is certain that morality has suffered many times not a little from its connection with theological creeds; that its truths have been appropriated and used to support demoralizing superstitions which were no part of it; that doctrines essentially immoral have been even taught in the name of religion; and that religious systems, in their struggles to establish their supremacy, have oftentimes shown small respect to the claims of morality. Had religion been true to its nature and function, as wide as morality and humanity, it should have been the bond of unity to hold mankind together in one brotherhood, linking them in good feeling, good will, and good work toward one another; but it has in reality been that which has most divided men, and the cause of more hatreds, more disorders, more persecutions, more bloodshed, more cruelties, than most other causes put together. In order to maintain peace and order, therefore, the state in modern times has been compelled to hold itself practically aloof from religion, and to leave to each hostile sect liberty to do as it likes so long as it meddles not by its tenets and ceremonials with the interests of civil government. Is it not, then, fortunate for the interests of morality that it is not bound up essentially with any form of religious creeds, but that it survives when creeds die, having its more secure foundations in the hard-won experience of mankind?

THE STERN AND UNIFORM REIGN OF LAW IN NATURE.

The inquiry which, taking a sincere survey of the facts, finds the basis and sanction of morality in experience, by no means arrives in the end at easy lessons of self-indulgence for the individual and the race, but, on the contrary, at the hardest lessons of self-renunciation. Disclosing to man the stern and uniform reign of law in nature, even in the evolution and degeneracy of his own nature, it takes from him the comfortable but demoralizing doctrine that he or others can escape the penalty of his ignorance, error, or wrongdoings either by penitence or prayer, and holds him to the strictest account for them. Discarding the notion that the observed uniformity of nature is but a uniformity of sequence at will, which may be interrupted whenever its interruption is earnestly enough asked for—a notion which, were it more than lip-doctrine, must necessarily deprive him of his most urgent motive to study patiently the laws of nature in order to conform to them—it enforces a stern feeling of responsibility to search out painfully the right path of obedience and to follow it, inexorably laying upon man the responsibility of the future of his race. If it be most certain, as it is, that all disobedience of natural law, whether physical or moral, is avenged inexorably in its consequences on earth, either upon the individual himself, or more often, perhaps, upon others—that the violated law cannot be bribed to stay its arm by burnt-offerings nor placated by prayers—it is a harmful doctrine, as tending directly to undermine understanding and to weaken will, to teach that either prayer or sacrifice will obviate the consequences of want of foresight or want of self-discipline, or that reliance on supernatural aid will make amends for lack of intelligent will. We still pray half-heartedly in our churches, as our forefathers prayed with their whole hearts, when we are afflicted with a plague or pestilence, that God will "accept of an atonement and command the destroying angel to cease from punishing;" and when we are suffering from too much rain we ask him to send fine weather, "although we for our iniquities have worthily deserved a plague of rain and waters." Is there a person of sincere understanding who, uttering that prayer, now believes it in his heart to be the successful way to stay a fever, plague, or pestilence? He knows well that, if it is to be answered, he must clean away dirt, purify drains, disinfect houses, and put in force those other sanitary measures which experience has proved to be efficacious, and that the aid vouchsafed to the prayer will only be given when these are by themselves successful. Had men gone on believing, as they once believed, that prayer would stay disease, they would never have learned and adopted sanitary measures, any more than the savage of Africa who prays to his fetich to cure disease does now. To get rid of the notion of supernatural interposition was the essential condition of true knowledge and self-help in that matter.

THE EVENTS OF THE MORAL WORLD ARE MATTERS OF LAW AND ORDER.

Many persons who could not confidently express their belief in the power of prayer to stop a plague or a deluge of rain, or who actually disbelieve it, still have a sincere hold of the belief of its miraculous power in the moral or spiritual world. Nevertheless, if the matter be made one simply of scientific observation, it must be confessed that all the evidence goes to prove that the events of the moral world are matters of law and order equally with those of the physical world, and that supernatural interpositions have no more place in the one than in the other; that he who prays for the creation of a clean heart and the renewal of a right spirit within him, if he gets at last what he prays for, gets it by the operation of the ordinary laws of moral growth and development, in consequence of painstaking watchfulness over himself and the continual exercise of good resolves. Only when he gets it in that way will he get the benefit of supernatural aid; and, if he rests in the belief of supernatural aid, without taking pains to get it entirely in that way, he will do himself moral harm; for if he cannot rely upon special interpositions in the moral any more than in the physical world, if he has to do entirely with those secondary laws of nature through which alone the supernatural is made natural, the invisible visible, it needs no demonstration that the opposite belief cannot strengthen, but must weaken, the understanding and will. It is plain that true moral hygiene is as impossible to the savage who relies upon his fetich to change his heart in answer to prayer, as sanitary science is impossible where he relies upon his fetich to stay a pestilence in answer to prayer.

THE GOOD OF MANKIND THE TRUE OBJECT OF LIFE.

So far from materialism being a menace to morality, when it is properly understood, it not only sets before man a higher intellectual aim than he is ever likely to reach by spiritual paths, but it even raises a more self-sacrificing moral standard. For when all has been said, it is not the most elevated or the most healthy business for a person to be occupied continually with anxieties and apprehensions and cares about the salvation of his own soul, and to be earnest to do well in this life in order that he may escape eternal suffering and gain eternal happiness in a life to come. The disbeliever might find room to argue that here was an instance showing how theology has taken possession of the moral instinct and vitiated it. Having set before man a selfish instead of an altruistic end as the prime motive of well-doing—his own good rather than the good of others—it is in no little danger of taking away his strongest motive to do uprightly, if so be the dead rise not. Indeed, it makes the question of the apostle a most natural one: "If, after the manner of men, I have fought with beasts at Ephesus, what advantageth it me if the dead rise not?" Materialism cannot hesitate in the least to declare that it is best for a man's self, and best for his kind, to have fought with the beasts of unrighteousness at Ephesus or elsewhere, even if the dead rise not. Perceiving and teaching that he is essentially a social being, that all the mental faculties by which he so much excels the animals below him, and even the language in which he expresses his mental functions, have been progressive developments of his social relations, it enforces the plain and inevitable conclusion that it is the true scientific function, and at the same time the highest development, of the individual to promote the well-being of the social organization—that is, to make his life subserve the good of his kind. It is no new morality, indeed, which it teaches; it simply brings men back to that which has been the central lesson and the real stay of the great religions of the world, and which is implicit in the constitution of society, but it does this by a way which promises to bring the understanding into entire harmony with moral feeling, and so to promote by a close and consistent interaction their accordant growth and development; and it strips morality of the livery of superstition in which theological creeds have dressed and disfigured it, presenting it to the adoration of mankind in its natural purity and strength.—*Fortnightly Review.*

* There appears to be no doubt that Confucius, among others, had the clearest apprehension of it and expressly taught it; and the Buddhist religion of perfection is certainly founded upon self-conquest and self-sacrifice. They are its very corner-stone: the purification of the mind from unholy desires and passions, and a devotion to the good of others, which rises to an enthusiasm for humanity, in order to escape from the miseries of this life and to attain to a perfect moral repose. "Let all the sins that have been committed fall upon me, in order that the world may be delivered," Buddha says. And of the son or disciple of Buddha it is said: "When reviled he revileth not again; when smitten he bears the blow without resentment; when treated with anger and passion he returns love and good-will; when threatened with death he bears no malice."

DIARRHEA.

At this season of the year diarrhea is very prevalent, and forms a not inconsiderable item in the mortality returns, especially among children. It exhibits all shades of severity, from a mere temporary attack, which is all over in an hour or two, up to fatal attacks of cholera. It becomes epidemic during the autumn months. Unripe or over-ripe fruit has a great deal to do with such outbursts, more particularly in children. The poor often buy fruit from costermongers which is "going off," and being cheap, a large amount is eaten, often followed by a severe attack of pain, sickness, and copious evacuations, which may readily yield to treatment, or may pass into the more serious and fatal forms, death resulting in a few hours.

In order to fully understand the subject, it may be well briefly to state the chief anatomical and physiological characteristics of the alimentary canal. Commencing at the lips, we have the cavity of the mouth, in which the food is received, whilst it is subjected to the grinding and cutting of the teeth, thoroughly mixed with the saliva, to render the bolus moist and capable of being swallowed, at the same time that this secretion acts upon all starchy matter, converting it into grape-sugar; when the mass is sufficiently masticated it is carried on, by the action of the tongue, to the back of the throat (the cheeks being closely applied to the teeth, prevent any escape outside these), and then passes down the œsophagus, or gullet, to the stomach. In the early part of this process two dangers have to be avoided. One is that the food may escape through the nostrils, which open into the upper part of the throat; this is prevented by the soft palate, which, together with the muscles passing on either side from the palate to the tongue and pharynx, completely shut off this cavity from the mouth during the process of deglutition, and form an inclined plane to direct the morsel downward. The other, and far more serious danger, is to prevent any food passing into the windpipe. The mechanism for this purpose is very perfect. At the base of the tongue is placed a somewhat triangular-shaped piece of cartilage, the apex being attached, the other and larger part free. Just as the bolus is entering the throat, certain muscles pull up the pharynx to receive it, and at the same time also raise the windpipe, so that its upper opening is covered by the piece of cartilage before mentioned (called the epiglottis), like a lid covering a box. Syphilis often destroys this epiglottis, or renders it imperfect, when all the phenomena of suffocation may arise from portions of food blocking the air tube.

Arrived in the stomach, the process of digestion proceeds more slowly—the food is subjected to the action of the gastric juice, an acid fluid containing pepsin. Each aperture of the stomach is guarded by a valve; the one where the gullet ends is called the cardiac valve; the other, where the stomach opens into the small intestine, is called the pylorus. During digestion each of these valves is closed, only opening to admit fresh portions, or to allow digested material to pass. This action resolves the swallowed material into a "characteristic thick, pultaceous, grumous consistence, with the undigested portions of the food mixed in a more fluid substance, and a strong, disagreeable acid odor and taste," and this goes by the name of "chyme." As successive portions of the food are reduced into this state, the pylorus opens and allows its passage into the commencement of the small intestines. During the time of digestion the stomach is in a state of constant motion, so as thoroughly to mix the food with the gastric juice, and to expose every part fully to its action.

Albuminoids, which, in their natural state, are non-diffusible, and therefore could not be absorbed by the blood vessels, undergo a change which renders them capable of absorption, and these are called peptones.* A certain amount of absorption of all soluble substances goes on during the time the swallowed materials remain in the stomach, and a certain amount of starch is converted into sugar by the saliva which is swallowed, but not to any great extent, for the acid gastric juice interferes with this. The juice itself has no action on starchy matters whatever. Fats are reduced into minute particles and mixed with the chyme.

The food has now arrived in the intestines, a long muscular tube measuring 24 feet to 26 feet, and divided into two portions, the small and large, the point of division being marked by a special valve, called the ileo-cæcal valve, which allows a free passage from the small into the large bowel, but effectually prevents any regurgitation of the contents of the latter into the former. The small intestine is about 20 feet long. This long tube occupies the greater part of the abdomen, and is arranged in coils. It is supplied with two layers of muscular fibers—one a longitudinal, which draws up or shortens any given part; and a circular, which, gradually contracting downwards, forces on its contents. This combination of movements is called peristaltic or vermicular, and passes downward in the form of a wave, and may be well seen by opening the abdomen of a recently-killed animal, when, on the entrance of the air, these peculiar movements are excited. In health, these movements are not perceived, but under certain circumstances give rise to much griping pain. At the lower part of the large intestine, called the rectum, these circular fibers form a thick band, called the internal sphincter, and a little lower down is another band called the external sphincter, and it is by the constant contraction of these that we are enabled to confine the contents of the bowel until such time as it is convenient to discharge them. All these actions are under the control of the nervous system, and can be increased, lessened, or suspended by it; and this readily explains the curious result of mental states over this part of the body.

Just after leaving the stomach, the chyme comes into contact with the bile and pancreatic fluids, and the whole length of the intestinal canal pours out a juice called the *succus entericus*. All of these are more or less alkaline, and acting upon the acid contents of the stomach as they are discharged, soon render them alkaline also. In the small intestine the digestion of fat chiefly goes on—the fatty matters become emulsified by admixture with bile and pancreatic juice, and are then absorbed by the "villi," little processes in the mucous membrane of the small intestine, containing a minute vessel called a lacteal, into which the fat passes. After being emulsified the mass is called "chyle." The pancreatic fluid also converts starch into sugar. Liquids and all soluble matters are readily absorbed as the mass goes down the small bowel and passes the ileo-cæcal valve as a thin pultaceous mass, of a light yellow color, and a distinctly fæcal odor. In the large intestine a vigorous absorption of fluid goes on, but probably no further digestion of fat, as there are no villi. At last nothing remains but the undigested or chemically modified residue of the food and certain matters derived from intestinal secretion, and this is discharged from the rectum as the fæces, the average quantity evacuated in 24 hours by an adult being 6 to 8 oz. Looking to the large quantity taken in by the mouth during that time, the very large quantity of the different secretions, and the small quantity discharged, we shall be able to realize how perfect and well adjusted is the balance between secretion and absorption. To appreciate the large circulation of fluid from the various organs into the intestines to aid in digestion, and then back into the vessels by absorption, it is only necessary to mention the average daily secretion of the various digestive juices:

"The quantity of saliva secreted in 24 hours varies, but its average amount is probably from 1 to 2 lb." (Harley.)

"The quantity of gastric juice secreted daily has been variously estimated, but the average for a healthy adult may be assumed to range from 10 to 20 pints in the 24 hours." (Brinton.)

"It has been estimated that 12 to 16 oz. of pancreatic fluid are secreted daily in the human subject."

"Various estimates have been made of the quantity of bile discharged into the intestines in 24 hours, the quantity doubtless varying, like that of the gastric fluid, in proportion to the amount of food taken. A fair average of several computations would give 20 to 40 oz. as the quantity daily secreted by man."

The quantity of *succus entericus* is difficult to determine. The above extracts are taken from Kirke's "Physiology."

We are now in a position to discuss the causes of diarrhea. It may result from increased peristaltic action, so that the contents of the intestines are hurried on too rapidly for the proper digestive action to have its due effect, and a large quantity of fluid is thus lost, as well as nourishment, and the balance between secretion and absorption is at once lost, the blood is deprived of a large amount of fluid, and hence the pain, exhaustion, and thirst, which are prominent features. A second cause is excessive secretion, giving rise to irritation. Both of these causes may be more or less blended.

Diarrhea may be either symptomatic or irritative. When symptomatic it is only one, perhaps the most prominent, of the signs of a much more serious condition, and to the treatment of which it belongs; thus it comes under this head when occurring in typhoid fever, cholera, enteritis, dysentery, pyæmia, various fevers, Bright's disease. In such cases it is only part of the general condition, and does not come under our present category. Irritative diarrhea is that depending on the introduction of some irritant from without, as in the case of the irritant poisons, improper articles of diet, etc., or it may arise through the action of the nervous system—some people being so constituted that the slightest mental emotion is accompanied by diarrhea.

All bad hygienic conditions predispose to this state, such as overcrowding, impure water and air, uncleanliness, excessive fatigue, and especially emanations from decomposing animal matter. Improper diet is a very constant factor, imperfectly cooked food, meat somewhat tainted, unripe or over-ripe fruit. Certain articles of diet will also give rise to this condition in certain individuals, this being a special idiosyncrasy.

Its symptoms are sufficiently obvious—the individual is suddenly seized with twisting pains about the navel, which may extend all over the stomach, but more frequently are limited as above stated; there is also generally more or less severe sickness, and a constant desire to go to stool, with the discharge of more or less copious fluid, which gives rise to much irritation and soreness about the anus. The pain is sometimes very severe, and there may be blood in the stools. The patient soon becomes weak, thirsty, tongue furred, pale, with tendency to faintness. After a time all may pass off; or cramps occur about the limbs, face becomes pinched, of a bluish tinge; there is more or less constant discharge of a watery fluid, and death soon closes the scene. It is always important carefully to examine the stools, to see whether there is any blood, and to obtain an accurate idea

* Peptones differ from albuminoids in being diffusible, not being precipitated by heat, nitric acid, acetic acid, or ferrocyanide of potassium. They are thrown down by tannic acid and perchloride of mercury.

as to the nature of the discharge. It is most important to bear in mind that these are the very symptoms that may arise in cases of poisoning by arsenic, antimony, etc., and to be on one's guard. "Symptoms of irritant poisoning, as a class, are burning pain and constriction in throat and gullet, sharp pain, increased by pressure at pit of stomach, intense thirst, nausea and vomiting, followed by pain, tension, and tenderness of entire abdomen, and purging, attended with tenesmus, and frequently with dysuria" (Guy's "Forensic Medicine").

Drinking of cold water in large quantities, especially when the body is heated, may give rise to vomiting and diarrhea.

The treatment will be limited to those cases which are examples of ordinary summer or autumnal diarrhea. Where there is clear evidence of any irritant matter having been taken, it is the proper course to get rid of it by a dose of castor-oil, with a drop or two of laudanum, to prevent any griping, and, after this has operated, to commence the ordinary astringent treatment. Generally, however, patients have been purged for hours before they seek advice, and hence all irritating matters have been discharged, and it is well at once to endeavor to check it.

Diet is a most important element; the tongue is usually furred, the digestion seriously impaired, so that it is important to give very bland and easily-absorbed food. Milk is most useful, and if there is much vomiting it may be given with lime-water or soda water—the latter making a most refreshing and agreeable beverage when thirst is greatly complained of. Starchy foods are of great value, as they tend to constipate, and so serve the double purpose of food and astringent. Rice, sago, arrowroot, corn-flour, are all most useful. Starch itself, made rather thick and eaten, will sometimes prove of the greatest service. All solid food must at once be stopped. Ice will be found most useful. As to stimulants, in the majority of cases they are not needed. They give temporary relief at the cost of increasing thirst, and produce a feverish reaction. They should only be used in cases of urgent danger and as substitutes until something better can be obtained. Hot, dry flannels to the stomach may relieve the pain, especially if sprinkled with a little turpentine. If the feet are cold, hot water bottles should be applied; and if there are cramps in the limbs, mustard plasters should be at once applied, as also over the heart, should there be any sign of its flagging.

As to medicines, opium comes first of all—it may be given either in the solid form as a pill, or combined with sulphuric acid in the form of laudanum. A most useful mixture, and one that rarely fails, is acid. sulph. dil. ʒ jss., tinct. opii, ʒ jss., aq. ʒ viij.—1/8 part four hours. The old chalk mixture, with opium, is useful, but is more suited to the case of children, with a little aromatic confection. If medicines do not seem to have much influence, use a small injection of starch and opium—about ʒ ij. of starch to 20 or 30 minims of laudanum; this, again, is most useful with children. For more obstinate cases, logwood, krameria, nitrate of silver, acetate of lead, sulphate of copper—the latter three used in the form of pills. It is well, for some days after the attack is over, to carefully regulate the diet, so as to prevent a return. Tonics will be needed to complete the cure when there has been much depression.—*M.R.C.S., Chemist and Druggist.*

NITRITE OF AMYL.

THE exact amount of vascular dilatation produced in frogs by the inhalation of nitrite of amyl has been carefully investigated at Heidelberg by Dr. Gaspey, who has detailed the observations in Virchow's *Archiv.* On the uninjured tongue of the frog the dilatation occurred immediately in both arteries and veins, and increased during the first two minutes. The duration of the dilatation depended upon the duration of the inhalation; if the latter was continued for two minutes, the dilatation lasted from ten to fifteen minutes. The amount of dilatation was at least one-third of the original diameter of the vessel. The rapidity of the blood-current remained about the same; in the first movement after dilatation it appeared somewhat quickened, but always quickly returned to the normal. In order to ascertain whether the nitrite of amyl acts upon vessels which are already dilated by some other means, irrigation of the frog's tongue with a solution of salt was employed, which is known to cause dilatation of the vessels and retardation of the blood-current. Amyl nitrite was found to still produce its effect, although in less degree—amounting to about one-fifth of the original size of the vessel. Experiments on the effect of the amyl in distant parts showed that the changes in the web of the frog's foot differed somewhat from those observed in the tongue. The dilatation occurred in about the same time, but was slighter. There was an immediate but very transient increase in the rapidity of the blood-current, followed by a distinct retardation.

Another point investigated was the effect of the amyl on tissues in which inflammation is going on. Its action on an inflamed tongue was found to be essentially the same as on the uninjured tongue, thus confirming an interesting observation of Mr. Talfourd Jones that hemorrhage after injury may be increased by the amyl. Other observations on the frog's mesentery showed that the process of inflammation was not in the least interfered with by the inhalation. The migration of the white corpuscles was not lessened. It is known, however, by the experiments of Thorma and Appen, that as a rule, whatever accelerates the blood-current lessens migration, and whatever retards the blood-current favors migration. It seems, therefore, that the influence of amyl nitrite on the inflammatory process may be different according to the position of the part, since retardation of the current was observed in the frog's foot and was not observed in the tongue.

THE STIGMATA OF MAIZE AND THE ARENARIA RUBRA IN DISEASES OF THE BLADDER.

As the stigmata of maize are a very recent and as yet but little known addition to the materia medica, the following *résumé* of the conclusions reached by Dr. Dufau, both from personal observation and from the reports of others, will undoubtedly prove interesting:

1. The stigmata of maize have a very marked, though not always a favorable action in all affections of the bladder, whether acute or chronic.

2. In acute traumatic cystitis, and also in gonorrhœal cystitis, they have a very marked diuretic action, but at the same time increase the pain; hence they should not be employed in these cases.

3. The best results have been obtained in cases of uric or phosphatic gravel, of chronic cystitis, whether simple or consecutive to gravel, and of mucous or muco-purulent catarrh. All the symptoms of the disease, the vesical pains, the dysuria, the excretion of sand, the ammoniacal odor, etc., etc., rapidly disappear under the influence of the medicine.

4. The retention of urine dependent on these various affections often disappears as improvement progresses, but the use of the sound must sometimes be continued, in order to empty the bladder completely.

5. The stigmata of maize have very often produced a cure after all the usual internal remedies had been tried in vain, or with only partial success. In other cases the ordinary methods of treatment, which had at first proved more or less entirely useless, became efficacious after the stigmata had been administered for a time, and had, as it were, broken the ground for them. Most frequently the stigmata alone sufficed for the cure, but still in some cases the effect was incomplete, and it was found that the treatment could be varied with benefit. Injections and irrigations of the bladder also proved useful adjuncts to the maize.

6. As the stigmata of maize are a very powerful, though at the same time entirely inoffensive diuretic, they have also been employed with the best results in cases of heart disease, albuminuria, and other affections requiring diuretics. Cases have been reported in which the urinary secretion was tripled and even quintupled in the first twenty-four hours, and others where the exhibition of the drug was continued for two or three months without the slightest untoward effect.

7. The best preparations of the stigmata are the extract and a sirup made from it. The decoction is unreliable and uncertain. The sirup, the usual dose of which is two or three teaspoonfuls per diem, must be largely diluted, and for this purpose either hot or cold water or a decoction of the stigmata may be used. The taste of this mixture is very agreeable. It should be given fasting.

Another remedy for diseases of the bladder that has lately begun to attract attention, is the *Arenaria rubra*, a plant of the order of caryophylleæ. It is known in Algeria by the common name of *sabline*, and has long enjoyed repute in Malta and Sicily as a household remedy for the treatment of gravel and catarrh of the bladder. It seems to be useful in the same line of cases as the stigmata of maize, but as yet our knowledge concerning its powers and uses is very limited.—*Le Courier Médical.*

PROMOTION OF PUBLIC HEALTH.

To the Editor of the Scientific American:

Seeing the immense annual loss to the State through the yellow fever scare, I think it the duty of every engineer to give you his opinion freely as to a possible remedy for the present unsatisfactory state of the sanitary condition of the Mississippi valley. I therefore offer this as my apology for trespassing on your time with my nostrum; hoping that out of the many plans that will doubtless be laid before you, you will be able to find out the right one, and advocate it in your valuable paper.

Having constructed very extensive sewerage works in England, and having carefully studied every system adopted in Europe, I have come to the conclusion that the right plan for stamping out fevers and all zymotic diseases has not yet been tried.

I would propose to have sewers merely for the discharge of storm waters and other inoffensive liquids, and I would treat human excreta, both solid and liquid, with *dry earth*, which is a perfect disinfectant, cheap and plentiful.

Each corporate body or board of health should hold, in fee, a farm outside the limits of the city; a farm to vary in size according to the population to be dealth with.

From this farm a certain amount of dry pulverized earth should be supplied daily to a certain number of houses.

Each house should be supplied with a duplicate set of zinc buckets, so that the scavenger who supplies the house with dry earth may take back to the farm the offal of said house, rendered harmless and inoffensive by being mixed with earth previously supplied.

This forms a valuable manure, which may be used to raise crops on the corporation farm or sold to other farmers, who would be glad to purchase it once they knew its immense value as a fertilizer.

This may look to be a complicated arrangement; but it is simple and not a tithe of the expense of the present ruinous system of sewerage by water carriage. In fact, I am convinced that if carried out by an energetic man, acquainted with farming operations and equal to the management of a large staff of men and horses, the dry earth system could be made a source of profit instead of expense to any city.

In addition to the above plan roughly sketched out, there are many other details to be looked closely after which are sadly neglected in large cities.

No accumulation of filth should be allowed in any part of a city, either by rich or poor.

No manure heap should be allowed to accumulate in or near any stable or house.

The compulsory whitewashing, inside and outside, of stables and the dwellings of the poor should be insisted on by fearless inspectors, who will do their duty without fear or favor, and should be properly paid for so doing.

Lime for whitewash should be supplied at cost price by the corporation.

Public abattoirs should be constructed outside the limits of the city, and no private slaughter houses allowed on any pretense. They are always kept filthy, and are the hotbeds of fever.

Blood mixed with dry earth is a most valuable manure, and will pay a fair interest for the construction of public abattoirs.

The overcrowding of lodging houses should be strictly prohibited; each lodging house being licensed for a certain number, and constantly under the supervision of an inspector.

Public baths at a cheap rate should be constructed, so as to entice the poorer classes into habits of cleanliness. These baths would be self supporting, and would become more popular every year.

In low lying districts no cellars should be allowed. They are generally made receptacles for filth of some sort, and if constructed below the level of existing sewers are certain to give off dangerous exhalations. On no account should cellars be occupied as sleeping apartments.

Where it is known that a contagious disease has existed in a house, it is the duty of the sanitary inspector to *personally oversee* the thorough disinfection of said house. This is a most important point, almost totally overlooked in cities; and the neglect of this all-important precaution causes the annual loss of many valuable lives in every State.

WATER SUPPLY.

Of course an abundant supply of pure water is a *sine qua non* in the health of a city; but I think there is an important point that wants looking to in hot climates: that is, the storage of water in open reservoirs. This, I think, should be attended to. All reservoirs in hot climates should be covered in, and completely protected from the rays of the sun.

Now, all these details, if properly carried out, doubtless involve a large expenditure of public funds; but see what you get rid of—

The annual loss of trade to the South. How many millions?

The annual loss of life. How many thousands?

The dread of every city becoming a Memphis.

The great deterioration of property in fever stricken districts, and the complete stoppage of the tide of immigration, which, if allowed to flow, would quickly develop the boundless resources of this magnificent country, and render it the storehouse of the world.

A SANITARY ENGINEER.

HEALTH AND RECREATION.

THE summer vacation is practically closed. The shortening days and the approach of foul weather have already reopened the offices of many of our physicians. They have been out for recreation and have returned ready for work. They have sought recreation, believing it to be an essential to the proper preservation of health and the prolongation of life. They indorse the work and play side of the question, and regard the one as essential as the other if the best practical results are to be obtained. Not long since Dr. B. W. Richardson, F.R.S., delivered a lecture at the London Institution, in which he took the position that, both in the young and the old, there was no difference between work and recreation other than one of sentiment. He believes that the reason why such excellence, physical and intellectual, was attained in the short and brilliant bloom of Greek history, was because in the Greek's career, from beginning to end, there was no such thing as work or play, but only life.

Commenting on this lecture, the London *Times* says that, if we could by some means approach the ideal handed down to us by history, we should in a generation or two attain a degree of health which no mere sanitary provisions, in the usual sense of the term, can ever supply, and the same sentiment is as practically applicable here as there. There are conditions of life, such as pertain to our climate and manner of living, which perhaps will prevent us from realizing the joyousness of Grecian life. But, besides these, there is the unequal struggle for existence, which dooms so many to the monotonous round of toil until the whole body lends itself to the drudgery like an automaton.

"There is a striking exception," says the learned lecturer, "in the happy class who find in mental labor, of a varied and congenial sort, that diversity of work which is truly a recreation of the healthy and vital powers." To confirm this view, he refers to the conclusion, reached by Dr. Beard, of this country, after examining the life-value of five hundred men of the greatest mental activity, and an equal number belonging to the rest of society—which is, that the brain-workers have a life-value greater by fourteen or twenty years than those whose pursuits are chiefly physical. Dr. Richardson, as well as others, have ascertained that the most influential in prolonging human life is the recreative character of intellectual labor.

Again, the *Times* alludes to Dr. Beard, who describes brain-work as the highest of all antidotes to worry. Scientists, physicians, lawyers, clergymen, orators, statesmen, literati, and merchants, when successful, are happy in their work without reference to reward, and work on in their callings long after the necessity has ceased. Good fortune gives good health, and nearly all the money in the world is in the hands of brain-workers, whose life is one long vacation.

Whether it be true or not that the difference between work and recreation is merely sentimental, there is comfort in mental and physical recreation which can be obtained only by absenting one's self from the drudgery of routine and, to a great extent, automatical labor. A grain of consolation for so doing can be obtained from Plato, who warned his readers against over-cultivation of mind, which, so far from being recreative to the health of the body, would be positively injurious, just as an over-cultivation of muscular power might prove mischievous.

Profiting by the suggestion, we may, therefore, avail ourselves of every opportunity that presents itself to resort to the seashore or to the mountains, in the belief that by so doing all life will be made healthier, happier, and longer.—*Medical Record.*

INSTRUCTIONS FOR DISINFECTION, PREPARED FOR THE NATIONAL BOARD OF HEALTH, 1879.

DISINFECTION is the destruction of the poisons of infectious and contagious diseases.

Deodorizers, or substances which destroy smells, are not necessarily disinfectants, and disinfectants do not necessarily have an odor.

Disinfection cannot compensate for want of cleanliness nor of ventilation.

I.—DISINFECTANTS TO BE EMPLOYED.

1. Roll-sulphur (brimstone) for fumigation.
2. Sulphate of iron (copperas) dissolved in water in the proportion of one and a half pounds to the gallon; for soil, sewers, etc.
3. Sulphate of zinc and common salt, dissolved together in water in the proportions of four ounces sulphate and two ounces salt to the gallon; for clothing, bed-linen, etc.

NOTE.—Carbolic acid is not included in the above list for the following reasons: It is very difficult to determine the quality of the commercial article, and the purchaser can never be certain of securing it of proper strength; it is expensive when of good quality, and experience has shown that it must be employed in comparatively large quantities to be of any use; it is liable by its strong odor to give a false sense of security.

II.—HOW TO USE DISINFECTANTS.

1. *In the sick-room.*—The most available agents are fresh air and cleanliness. The clothing, towels, bed-linen, etc., should, on removal from the patient, and before they are taken from the room, be placed in a pail or tub of the zinc solution, boiling-hot if possible.

All discharges should either be received in vessels containing copperas solution, or, when this is impracticable, should be immediately covered with copperas solution. All vessels used about the patient should be cleansed with the same solution.

Unnecessary furniture—especially that which is stuffed—carpets and hangings, should, when possible, be removed from the room at the outset, otherwise they should remain for subsequent fumigation and treatment.

2. *Fumigation* with sulphur is the only practicable method

for disinfecting the house. For this purpose the rooms to be disinfected must be vacated. Heavy clothing, blankets, bedding, and other articles which cannot be treated with zinc solution, should be opened and exposed during fumigation, as directed below. Close the rooms as tightly as possible, place the sulphur in iron pans supported upon bricks placed in wash-tubs containing a little water, set it on fire by hot coals, or with the aid of a spoonful of alcohol, and allow the room to remain closed for twenty-four hours. For a room about ten feet square, at least two pounds of sulphur should be used; for larger rooms, proportionally increased quantities.

3. *Premises.*—Cellars, yards, stables, gutters, privies, cesspools, water closets, drains, sewers, etc., should be frequently and liberally treated with copperas solution. The copperas solution is easily prepared by hanging a basket containing about sixty pounds of copperas in a barrel of water.

4. *Body and Bed Clothing, etc.*—It is *best* to burn all articles which have been in contact with persons sick with contagious or infectious diseases. Articles too valuable to be destroyed should be treated as follows:

(*a*.) Cotton, linen, flannels, blankets, etc., should be treated with the boiling-hot zinc solution; introduce piece by piece, secure thorough wetting, and boil for at least half an hour.

(*b*.) Heavy woolen clothing, silks, furs, stuffed bed-covers, beds, and other articles which cannot be treated with the zinc solution, should be hung in the room during fumigation, their surfaces thoroughly exposed, and pockets turned inside out. Afterward they should be hung in the open air, beaten and shaken. Pillows, beds, stuffed mattresses, upholstered furniture, etc., should be cut open, the contents spread out and thoroughly fumigated. Carpets are best fumigated on the floor, but should afterward be removed to the open air and thoroughly beaten.

5. *Corpses* should be thoroughly washed with a zinc solution of double strength; should then be wrapped in a sheet wet with the zinc solution, and buried at once. Metallic, metal-lined, or air-tight coffins should be used when possible, certainly when the body is to be transported for any considerable distance.

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SOME FACTS AND THOUGHTS ABOUT LIGHT-EMITTING ANIMALS.

By Professor P. Martin Duncan, M.B. Lond., F.R.S., etc.

After the glare of daylight has passed into night, during the warmest months of the year, countless little points of light are often to be seen on the turf and amongst the brake and underwood in the open country of the South of England. The light is distinct enough, and when scattered far and near over a hillside, is always a matter of wonderment to the observer who witnesses the sight for the first time. When curiosity impels any one to approach the little luminous points more closely, their "phosphorescent" gleam is evident enough, and the greenish white light glows. It increases and diminishes in its intensity, becomes bright and fades in a surrounding mistiness,and again flashes out more brilliantly than ever. Hour after hour the green and white illumination persists, but if any one point be carefully watched, it will be observed to cease occasionally for a second or two, and often to move about. Toward the darkest hours the luminous points become more numerous and brilliant; but midnight witnesses the paling of the light which "fadeth at the crowing of the cock."

Searching amongst the grass for the cause of this remarkable light, the hand feels no increase of temperature on approaching the objects which relate to it, and successful seeking discovers a cold, softish insect.

At the same time of the year, when the summer's sun has warmed the surface of the sea, the darkest nights during calm weather off the coasts of our islands are illuminated by fitful flashes of green, yellow, blue, and rarely red light, which, starting suddenly from one or two spots on the water, spread on all sides in coruscations, or in glowing ripples and increasing breadths, to cease as suddenly as they began. A boat glides into some quiet, dark harbor and sets the sea "aflame;" every dip of the oar produces an extending circlet of light, every drop of spray is luminous, and adds to the sparkling as it falls, and the moving prow wells out little waves surging with tints of green and gold. Darkness, all the more intense by contrast, succeeds, to be again and again suddenly turned into transient light. In the offing, the sailors say the sea is "briny," and they watch the rippling radiance in their wake, and note the sudden gleams which, commencing at some disturbed spot of the surface, flash out on all sides. At anchor watch, whilst the night is as dark as pitch and the sea is hardly visible, the cable may often look white hot during the intervals of the faint illumination of the surface.

A bucket is lowered, and wood, ropes, hands, and arms are alight with liquid heatless fire, and myriads of tiny globes may be seen occasionally in the water, intensely luminous. On going ashore up the wet sands, often enough every footstep is a focus of radiating glimmers, and remains luminous for a while.

These common sights, passed by by most people, are supremely interesting to the thoughtful, and they are the feeble Northern extension of similar phenomena, which are grand indeed in the sub-tropical and torrid regions of the globe, and which, and even at some depth in the great oceans, may relieve the eternal darkness. But even on the verge of the sea, Nature's pyrotechny is superb, and Neptune is jealous of Nox, for in the short hour or two between the summer's daylight, spray, waves, and all they wash, are often intensely, long or momentarily, bright.

The dredge brings up, out of comparatively shallow water, Actinozoa, which, hitherto buried up to their tentacular ring, are light-emitting. A diver sees a luminous spot on the submerged limestone rock he is examining, and finds a boring shell smeared with luminosity. The weary sailor, tired with the monotony and the great heat of the tropical day, peering into the depths near the coral banks of North Australia and New Caledonia, sees long tracks of wandering light, and wonders at the graceful evolutions and fierce attacks of the sea-snakes, lit up as they are with a fiery path. Or, dreamily watching, he marvels at the radiant course of the predaceous fish as they rise to the surface and rush beneath, after their prey. Some whalers, when the ship is hove to and gently rolling in the dark nights of the Southern Ocean, see the mighty monsters shoot up above the gleaming surface amidst a fountain of lurid phosphorescent spray, and fall splashing again and again in ponderous play, as if they loved to show their strength amidst showers and waves of light. Sights such as these are not the invariable accompaniment of the darkness far away in Northern seas; for there the spreading phosphorescence of the surface often pales with the rising moon, or the display of the Aurora. But even then, mid-ocean becomes luminous as the tide carries the host of Medusæ along. Even when the moon is at its full, and the sea is bright with its luster, there is a world of light deep down below the surface. Great domes of pale gold with long streamers move slowly along in endless succession; small silvery disks swim, now enlarging and now contracting; and here and there a green or bluish gleam marks the course of the tiny but rapidly rising and sinking globe. Hour after hour the procession passes by; and the fishermen hauling in their nets from the midst, drag out liquid light, and the soft sea-jellies, crushed and torn piecemeal, shine in every clinging particle. The night grows dark, the wind rises and is cold, and the tide changes, so does the luminosity of the sea. The pale specters below the surface sink deeper, and are lost to sight; but the increasing waves are tinged here and there with green and white; and often along a line, where the fresh water is mixing with the salt in the estuary, there is a brightness so intense that boats and shores are visible. But if such sights are to be seen on the surface, what must not be the phosphorescence of the depths? Every Sea-pen is glorious in its light; in fact, nearly every eight-armed Alcyonian is thus resplendent; and the social *Pyrosoma*, bulky and a free swimmer, glows like a bar of hot metal, with a white and green radiance.

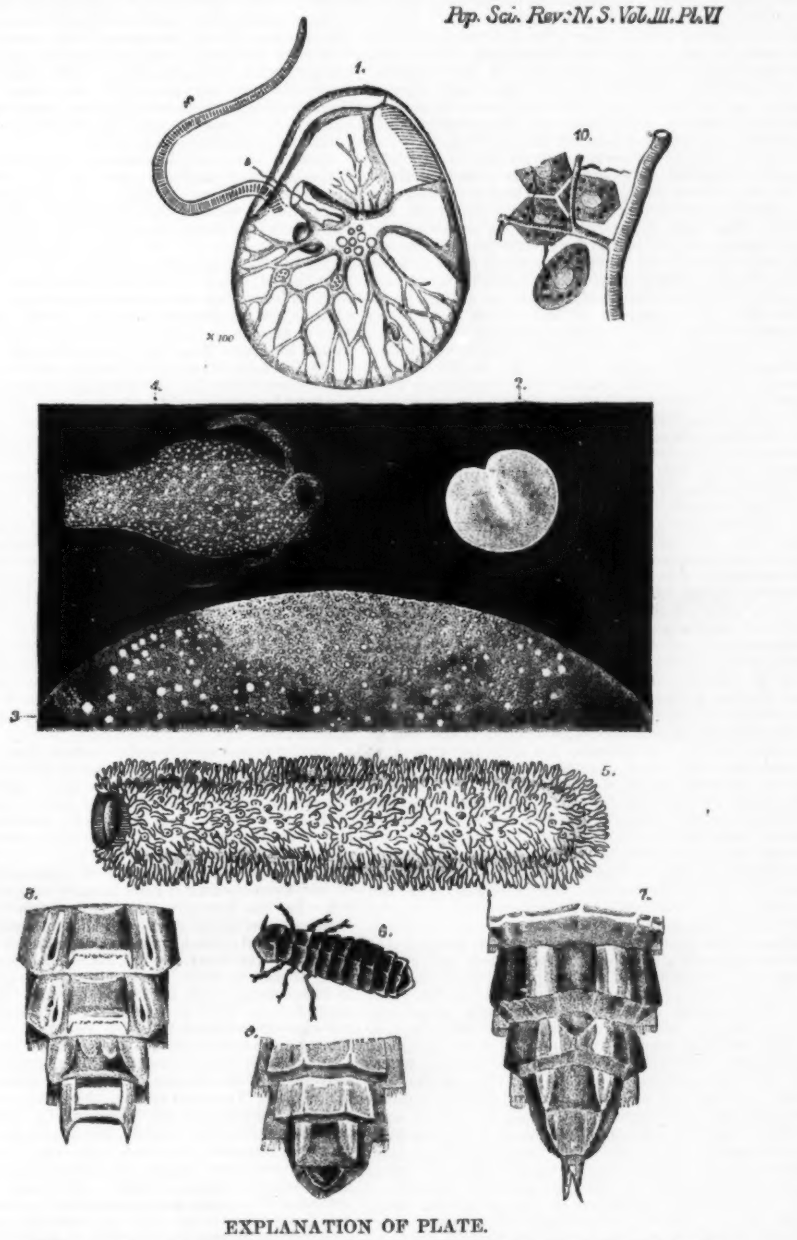
Just as in some places in England, the points of light on the turf may be seen simultaneously with the luminosity of the surface of the sea close by, so in the tropics, active and flying specks of brightness compete on shore with the diffused splendor of the coast. All this light, so vast in its world-wide amount, is heatless. Crowd it all together, and a vast city might be illuminated without raising the thermometer probably many degrees, if at all; and all this vibration, this consequence of intensely rapid molecular motion, is the result of the energy of life.

The points of light on the turf of the South of England are produced by a beetle—the "glowworm," *Lampyris;* and the genus is world-wide in its distribution. The fire flies of the tropics are principally Elater beetles, and others allied to them in classification; and there are Hemiptera as well as Myriopoda which add to the list. Our sea surface illumination is due to myriads of *Noctiluca miliaris*, and the same and other species of the genus are world-wide. The minuter Crustacea, the Alcyonarians, Medusæ, Polyzoa, Ophiurans, Tunicata, Annelida, and Mollusca, add species to the luminous assemblage; and probably more than one hundred and fifty genera, most of which have numerous species which are prolific in individuals, are luminous under certain circumstances. It is possible that some fish noticed by Dr. Günther are phosphorescent in the deep sea.

The intensity and the color of the light emitted, differ with the genus, species, locality, and season, and certain species have a definite and peculiar light. The English glowworm has a misty-colored light, which is usually greenish; that of Italy is brilliantly blue; whilst the Australian species emits a pulsating light. The fire-fly of the West Indies glows with a very white light; but it is doubtful if the *Fulgora*, so often seen in books as the Lantern fly, has a scarlet light, or any at all. The rapid coruscating flashes on the sea and on the sands are now and then yellow or white, but rarely scarlet, or reddish, and are produced by crustaceans. Other insects in the tropics give out a deep blue and white light; and the Pacific Islands hundred-legs produce a brilliant emerald green. *Noctiluca* gives out a greenish and often bluish light, and the Medusoids vivid yellow, gold, green, blue, and white tints. The Sea-pens give out white as well as colored light; and that of the Echinoderms is green. The green and white tints are the commonest colors, yellow is rare, and so are the reds and blues, whilst purples are unusual. The Gorgonoids give out a beautiful lilac.

A very slight examination of the animals connected with these luminous phenomena indicates that they are produced in different manners. For instance, *Noctiluca*, *Pholas*, and *Lampyris*, are readily anatomized, and the source of the luminosity is found to differ in each. Hence it is important to consider some typical cases which illustrate the varieties of light production.

Consider, first of all, *Noctiluca miliaris* (plate, Figs. 1–8), which is very common in the warm summer months all round the English coast, and up the Humber and British Channel. It is impossible to estimate the countless numbers of this



EXPLANATION OF PLATE.

Fig. 1. *Noctiluca miliaris*, magnified 100 diameters, showing the fibrillar structure; the flagellum (*f*); and the cilium at the oral aperture (*s*).
" 2. *Noctiluca miliaris*, slightly magnified and luminous.
" 3. *Noctiluca miliaris*, luminous portion highly magnified.
" 4. *Phyllirhoë bucephala*, showing the luminous spots.
Fig. 5. *Pyrosoma giganteum*, reduced in size.
" 6. *Lampyris noctiluca*, female, natural size.
" 7. The same; the luminous organs enlarged.
" 8. The male, its luminous organs magnified.
" 9. The larva, its luminous organs magnified.
" 10. Some light cells and their tracheæ magnified.

PHOSPHORESCENT ANIMALS.

minute, peach-shaped, flagellate infusorian in some parts of our seas. For instance, on the Essex coast some years since, I found every tumbler of sea water taken out between the Gunfleet sands and the mainland crowded with them; and most of the actively-moving, little gelatinous, transparent things were no larger than their standard of $\frac{1}{30}$ inch in diameter. They move by means of a filiform tentacle, of the diameter of the body; and about $\frac{1}{1500}$ inch in breadth, which is placed close to the opening of the so-called mouth. The tentacle is ong and flat, and has striations across it, but which appear to be beneath the delicate cuticle. A long, delicate, undulating fibril comes from the bottom of the oral cavity, and can be protruded and withdrawn, and close to it is a horny looking, tooth-like body, $\frac{1}{7500}$ inch long. The opening into the interior, or mouth, is the extremity of a funnel, which ends within, in the minutely granular substance forming the bulk of the body, and which, if it were perfectly transparent and uniform, no part being differentiated, might be called protoplasm. This granular sarcode has spaces in it containing water, or vacuoles, one often being large, but they do not contract and enlarge like those of many Protozoa. Radiating in meshes, which are coarse near the mouth and very minute and fibrillar near the outside, is a denser sarcode, and there are granules on the fibrils. These fibrillar meshes are enveloped in a minutely granular sarcode, and they reach to just under the surface of the animal, ending in a clear protoplasmic layer, which underlies the equally clear and transparent cuticle or cell wall. Near the vacuolated part is a small nucleus, and it is evidently in relation with the fibrillar radiations; and there are occasionally nucleated cell-like bodies in the peripheral layer of protoplasm. As these are probably spores, it is not necessary to consider them. Now there is movement in the striated tentacle and in the long filamentous cilium, and there is amœboid streaming of granules on the radiating fibrils, but no change of general shape constantly occurs. The animal respires by its outer cell wall, grows in size by additions to the finer granular parts, and the principal seat of this activity must be just beneath the cell wall.

Now, on watching *Noctiluca* in captivity, one is struck by the very vivid light which it emits. It is a sudden flash, lasting but for a short time, and is repeated over and over again, some intermission being apparently inevitable and necessary. The light is greenish, and is produced not especially near the seat of tentacular and fibrillar movement, but just under the cell wall. It arises from scores of minute, independent points, which scintillate and illuminate the rest; in fact, where respiration and assimilation are at their greatest, where the vital energy is in full action. Anything which increases this activity produces increase of the light, and the converse is true. Pure, highly aerated sea water, changed over and over again, adds to the brilliancy and persistence. Oxygen forced into the water produces more light, and the stimulation of fresh (non-saline) water at first does the same, but sooner or later it is destructive to the animal. Physical stimulation evidently acts on the light, and produces it for a time, and a *constant illumination* precedes death, when light ceases. The light diminishes *in vacuo*, and under the influence of carbonic acid gas.

Quatrefages experimented upon *Noctiluca*, and added alcohol; and this produced a definite, continuous luminous ring, and then a general peripheral illumination, which lasted for a while and until death. Finally, it is well known that nets which have been dragged out of a sea crowded with *Noctiluca*, retain light-emitting powers until the meshes become dry. The sunlight has nothing to do with the luminosity of *Noctiluca*.

The Spongidæ have not as yet been recorded as having luminous kinds, but the Hydrozoa teem with them; and moreover the gift, so common in the planoblasts, is found in some species in the stationary and vegetative animal. Probably nearly all Medusæ are luminous, and notably the larger *Aureliæ* and *Zygodactylæ*, whose light is decided, although like a dim halo sometimes, but grandly golden at others, and especially when the creatures are broken by hauling in. Agassiz noticed that the blue tint of the seeming phosphorescence was often due to a Medusa, *Dysmorphosa fulgurans*, which breeds others from its proboscis, and thus readily adds to its vast numbers. On the other hand, the stem or trophosome, out of which *Obelia* is developed, has a pulsating light running up it, whilst the free swimming disk is said to be non-luminous. The globular jelly fish with paddles, or the Ctenophora, so active in the sea, are brilliantly luminous, and it appears that many of the horny Sertularians give out light. The luminous part of the Medusæ is superficial when they are swimming and entire, and it appears to be restricted to the upper part of the umbrella, to the margin of the disk, and to the tentacles. But extreme irritation and tearing will develop light apparently everywhere, and the slippery semi-solid sarcode clings to everything, and is for a while luminous. It does not appear that the natural luminosity is greater underneath, where Schäfer has noticed radiating nerve fibers, than on the top, where there is a delicate epithelium, whose flat cells contain minute points of fatty matter, and where no nerves have been found. The tentacles get luminous, and they are without any evidence of nerve, except perhaps where they start from the margin of the umbrella or disk. There is often much defined light at the so-called eye spots at the edge of the disk, and it may be in relation to the epithelium there, related as this is to nerve In the mass of the animal there is no highly differentiated protoplasm, but there is much of a low character, and it is all this that is so golden and white, when rupture has taken place. It is hard to believe that the nerves and fatty matters have anything to do with the luminous phenomena here, and certainly they have not in the trophosome of *Obelia*. Protoplasm, in a state of active nutrition, appears to be the seat of the movement which produces the light wave.

It must be remarked that the great jelly fish of our coasts, and of other seas, are not luminous during the whole of their summer life, for they may be seen crowding many estuaries in the hot months, as the twilight merges into night, and not a sparkle of light is visible amongst them.

Phosphorescence does not appear to have been noticed in the reef-building corals, nor in those solitary ones which can be kept in aquaria, but some of the Actinidæ, or sea anemones, are brilliantly luminous. One notable example is the mud-loving, free, long-bodied *Iluanthos scoticus*, which leaves its rayed disk just above the surface of the ooze, shining like a star here and there, and retaining its light when brought up with the dredge. The extraordinary luminosity of vast numbers of the Alcyonarian Pennatulidæ and Gorgonidæ compensates for the comparative absence of the phenomena in the other members of their group. Even in the cold North Sea, the Sea-pens and their long-stalked, short polyped allies, the *Virgulariæ*, add to the sea light, and the *Gorgoniæ* do the same. They are resplendent in the Mediterranean; and Moseley states that all the Alcyonarians dredged up by the Challenger from deep water were found to be brilliantly light-emitting, and that their phosphorescence agreed in its manner of exhibition with that observed in shallow water forms. He examined the light emitted by three species of deep-sea Alcyonaria with the spectroscope, and found it to consist of the red, yellow, and green rays only.

Panceri notices the light of *Pennatula phosphorea*, which is an eight tentacled Alcyonarian, with a stem with pinnate branches, carrying zooids or polypes. The long stem reaching below the branches consists of canal tubes, which are in communication with the polypes through the branches; and it is covered with sarcode that is comparatively rudimentary, and which is liable to become infiltrated with water, or to be hydropic when brought up from the deep sea. The polypes, when fully expanded, are in rows on the upper surface of the branches, and each has eight pinnate tentacles, and at their base a slight swelling on the outside. From each of these eight swellings an opaque white cord passes down the outside of the visceral cavity of each polype to the sarcode of the branch.

These cords are canals in the sarcode, and when they are compressed their contents may pass either into the hollow of each tentacle, or backwards into the tubular cavities of the branchlets and stem, and very little force suffices to burst them. When examined under the microscope, the contents are found to be cells and a fluid, and the opacity and white color are produced by the cell contents, which consist of minute, highly refracting globular particles, having chemically and optically all the properties of fatty matter. This substance is remarkable for its persistence without undergoing decomposition long after the death of the polype. In the substance of the cords there are cells which are stellate in shape, with prolongations, and resembling multipolar ganglion nerve cells; and others are simple enlargements along the course of a fiber. Besides these there are many albuminoid granules and some white particles of a mineral nature, but which does not consist of carbonate or phosphate of lime.

Now this Sea-pen is luminous universally, when seen under favorable circumstances in the open sea, and it has its hours of darkness. When caught to be experimented upon, the animal lights up in a very remarkable and definite manner. Should the long supporting axial stem be pinched, the polypes nearest the stem on the lowest branchlets become sparklingly luminous one after the other, and when they are all illuminated, those of the next branchlets begin to shine, until in succession the whole are glowing. A slight interval of time, amounting to $\frac{1}{4}$ second, occurs between the stimulation and the appearance of the light, and the Sea-pen $6\frac{1}{10}$ inches long was illuminated in $2\frac{1}{4}$ seconds.

On pinching the top of a Sea-pen of this species, the lighting up commenced in the nearest polypes, and then those of the next lowest branchlets took up the effect, and the phenomena of the previous experiment were simply reversed.

Again, on irritating one of the polypes at the end of a branchlet, its luminosity went to its neighbor, and then all followed one after the other; and if those at the beginning and ending of a branchlet were touched, the lighting up was toward those in and between them.

This successional illumination is very decided, and when it is completed the light is pretty constant. But it is evident that on irritating one of the polypes it "takes fire," as it were, at the edge of the tentacular apparatus, some luminosity remaining on the implement and in the intermediate water.

These remarks, the results of Panceri's interesting studies, may recall to mind the early experiment of Spallanzani, who, on compressing the stem of a *Pennatula*, obtained a light from the other extremity, and the fact that crushing the stem and a few branchlets produces a *substance* which becomes diffused and lights up everything to which it adheres.

Careful observation has determined that when the pen is perfect, the light is emitted from the eight opaque cords of each polype, and that it can commence and continue without their rupture. On the other hand, rupture of a cord excites the luminosity of the whole, and the escaping fatty matter is luminous after its separation and after the death of the animal.

There is no sensible increase of temperature, and the tint of the monochromatic light is azure or greenish, but never red. In this beautiful instance of this remarkable vital luminousness there is evidently a photogenic structure and an elaborated organic material capable of producing light after removal from the animal. The sequence of illuminating is slow in the whole pen, and only at a rate of a yard in 20 seconds—a rate far less than that of the movement of nerve force. Yet the presence of the lowly organized nervous element indicates that the regulating of the light may relate to it as its function. Clearly the phosphorescence of the Pennatulid is in advance of that of the simpler protoplasmic movement of the Protozoa, and of the slime of the Actinoid. Sir Wyville Thomson notices the coming up in a trawl let down to a depth of 2,125 fathoms of a magnificent "clustered sea polype" (*Umbellularia grœnlandica*), consisting of "twelve gigantic Alcyonarian polypes, each with eight fringed arms, terminating in a close cluster on a calcareous stem ninety centimeters high." He states that when this splendid Pennatulid was taken from the trawl, the polypes and the membrane covering the hard axis of the stem were so brightly phosphorescent that Captain Maclear found it easy to determine the character of the light by the spectroscope. It gave a very restrictedly continuous spectrum, sharply included between the lines *b* and D.* The same naturalist writes, after dredging in 828 fathoms off St. Vincent, that the trawl "seemed to have gone over a regular field of a delicate, simple Gorgonoid, with a thin, wire-like axis slightly twisted spirally, a small tuft of irregular rootlets at the base, and long exsert polypes. The stems, which were from 18 inches to 2 feet in length, were coiled in great hanks round the trawl beam, and entangled in masses in the net, and as they showed a most vivid phosphorescence of a pale lilac color, their immense numbers suggested a wonderful state of things beneath—animated corn fields waving gently in the slow tidal current, and glowing with soft diffused light, scintillating and sparkling on the slightest touch, and now and again breaking into long avenues of vivid light, indicating the paths of fishes or other wandering denizens of their enchanted region."†

Again, in the "Voyage of the Porcupine,"‡ the same fortunate naturalist noticed the Sea-pen, *Pavonia quadrangularis*, which entangled the dredge with its pink stems a meter long, fringed with hundreds of polypes, to be "resplendent with a pale lilac phosphorescence like the flame of cyanogen gas, almost constant, sometimes flashing out at one point more brightly, and then dying gradually into comparitive dimness, but always sufficiently bright to make every portion of a stem caught in the tangles or sticking to the ropes distinctly visible."

* "The Atlantic," vol. i.; "The Voyage of the Challenger," p. 151. That is, in the green, near the less refrangible part.

† Thomson, *Op. cit.*, p. 119.

‡ Thomson, "Cruise of the Porcupine," p. 149.

Probably the grandest display of light-emitting is by the great cylindrical-looking *Pyrosoma*, one of the Tunicata (Pl., Fig. 5). This animal is really a compound one, and the common uniting tissue has the shape of a hollow cylinder rounded and closed at one end and cut short and open at the other. This is firm and transparent, like so much cartilage, and on its outside are arranged numerous whorls of separate zooids. Each zooid projecting is large near the supporting cylinder and smaller where free, and this end has the mouth opening, whilst the base is perforated by holes, which are continued through the cylinder. The water system thus opens into the hollow cylinder, and the water issuing from it propels the whole in the opposite direction, at the same time that it revolves on its long axis. In the Mediterranean the Pyrosomes are from two to fourteen inches in length, and they may be three inches in diameter; they are seen in great companies, and when floating and revolving just below the surface, look like incandescent rods of iron. The light is said to be polychroic in the Pyrosome of the Atlantic, or of a vivid green; and it is azure in a gigantic species. It does not come, according to Panceri, from every spot on the body, but from two round spots, one on either side of each of the zooids, situated over the position of the ganglia of the nervous system, and there are loops like cords passing over the narrow end connecting them (Figs. 1 and 2). They are

FIG. 1.—The open end of *Pyrosoma giganteum*, showing the zooids with their luminous spots.
FIG. 2.—The outer end of a single zooid, with luminous spots, enlarged.

placed between the two tunics of the integument, and are attached to the outer one. After a while the light becomes diffused over the whole surface. Panceri states that when the animal is not over-stimulated, the light is intermittent, and that it consists of sparks from the special cells in each zooid. The luminous bodies are photogenic structures, and produce an albuminoid substance, and also much that is soluble in ether. This matter may become diffused by handling, and retains its luminosity for some time. Panceri states that the light is increased by, and lasts long in fresh water. The largest kind of this wonderful light-emitting compound Tunicate is a grand sight in the night, as it gives out suddenly a vivid greenish light, large in its dimensions, and then it sinks to the depths. Moseley writes: "A giant Pyrosoma was caught by me in the deep-sea trawl. It was like a great sac, with its walls of jelly about an inch in thickness. It was four feet in length, and ten inches in diameter. When a Pyrosoma is stimulated by having its surface touched, the phosphorescent light breaks out at first at the spot stimulated, and then spreads over the surface of the colony as the stimulation is transmitted to the surrounding animals. I wrote my name with my finger on the great Pyrosome as it lay on deck in a tub at night, and my name came out in a few seconds in letters of fire."* Sir Wyville Thomson, noticing the "blaze of phosphorescence" off the Cape Verd Islands, states that the track of the ship was an avenue of intense brightness. "It was easy to read the smallest print sitting at the after-port in my cabin, and the bows shed on either side rapidly widening wedges of radiance, so vivid as to throw the sails and rigging into distinct lights and shadows. The first night or two after leaving San Iago, the phosphorescence seemed to be chiefly due to a large Pyrosoma, of which we took many specimens in the tow-net, and which glowed in the water with a white light like that from molten iron."†

All luminous animals are not illuminators of the surface water or deep sea, for some shine where their gift is not appreciated by others. The burrowing shell fish, *Pholas dactylus*, lives hidden up; but is nevertheless provided with photogenic structures and substances, and these are also nearly hidden in the enveloping tissues of the bivalve. The elongated cylindrical shells are well known objects in most cabinets, and it is only necessary to state that the animal has a large foot, and that the combined siphons are large, cylindrical, and furnished with fringed orifices. Now, the photogenic structures are two parallel cords, containing opaque white matter running down the anterior siphon, and two small triangular spots at the entrance of it, and, lastly, an arched cord corresponding with the superior edge of the mantle, reaching to the middle near the valves. The cords and spots are convoluted lobes of the mucous membrane. The cords stand out in relief, and their white color distinguishes them, and although they are only elevations of the subcuticular tissue, they contain special cells, or rather epithelium, which produces the phosphorescent matter. The whole surface of the *Pholas* is covered with ciliated epithelium, which dips down into all the parts of the animal;

* Moseley, "Notes of a Naturalist on the Challenger."

† "Voyage of the Challenger," ii., p. 85.

but the special epithelium differs from this. It is nucleated and crammed with granules, and the cells are very refractive. The cells are very fragile, and allow their contents, *i. e.*, granular nuclei and refractive granules, to escape readily. These are soluble in ether and alcohol. Under ordinary circumstances this photogenic apparatus is hidden; but violence readily displaces the special cells, which burst, and their contents are carried all over the surface by the water, assisted by the general ciliation. The white substance, fat-like, retains its luminosity when spread out on paper for hours, but the light does not appear to be accompanied by an evolution of heat. When it is placed in carbonic acid gas, the light pales and ceases. On the other hand the photogenic substance, when barely luminous, is rendered so by physical contact. Agitation, and the addition of fresh or salt water, develop the light, and the same effect is produced by electricity and by heat. The light is monochromatic, and has a constant place in the spectrum as an azure band from E to F, that is to say, in the green, but in the more refrangible part.

The luminosity of one of the sea slugs of the Mediterranean and Pacific, is as remarkable as the creature producing it. Living a pelagic life, swimming freely with a fan like vertical tail, this little transparent *Phyllirhoë bucephala* (Pl., Fig. 4) has no shell when in the adult stage, neither has it a foot, but its body is compressed and fish shaped, and it has a round and truncated muzzle, behind which are two long flexible tentacles. It has no branchiæ, and respiration appears to go on through the general surface. Now to add to the beauty of this translucent creature, light emission from many distinct round spots renders the tissues transparent and luminous. And when it is swimming vigorously, the whole surface shines with a diffused light. The sexes are combined in this delicate slug, which must be a nice morsel for many a fish, and which must find its phosphorescence a fatal gift. There does not appear, however, to be any special photogenic substance. The light comes from globular cells with an envelope terminating in the outer coat of a nerve. The cells are neucleated, and at first sight resemb'e Pacinian bodies without their internal structure. They nevertheless are terminations of nerves just under the cuticle (Fig. 4 *a*).

Some Ophiurans are brilliantly phosphorescent, and it may be said from our present knowledge that those which live at considerable depths are more so than the shallow water forms. Their luminosity has no reference to the temperature of the surface water; and such a species as *Ophiacantha spinulosa*, which has a great bathymetrical range, is intensely brilliant when dredged out of very cold water. Sir Wyville Thomson has given a very interesting description of the phenomena in "The Cruise of the Porcupine." He writes: "Some of these hauls were taken late in the evening, and the tangles were spangled over with stars of the most brilliant uranian green; little stars, for the phosphorescent light was much more vivid in the younger and smaller individuals. The light was not constant nor continuous all over the star; but sometimes it struck out a line of fire all round the disk, flashing, or, one might rather say, glowing up to the center; then that would fade, and a defined patch, a centimeter or so long, break out in the middle of an arm and travel slowly out to the point, or the whole five rays would light up at the ends and spread the fire inward. Very young *Ophiacanthæ*, only lately rid of their '*plutei*,' shone very brightly."

The position of the luminosity is removed from the nervous cords, and in decalcified specimens I have failed to trace nervous filaments on the top of the disk and in the substance, or near the upper arm plates of the rays. But in a specimen from the Icy sea of North Smith's Sound, collected during Sir George Nares' expedition, and sent to me for description, I traced a filmy mucous covering here and there, which seemed to be an exaggeration of the excessively thin epiderm which evidently, in the young forms, covers the plates and the bases of the spines. The disk is covered with a crowd of minute spicular projections, each terminating in a bunch of small thorny knobs, or in three, four, or more rather sharp spicules. These delicate appendages are developed within the skin, as are also the granular elements which constitute the plates of the arms. It is possible that the luminous property resides in this delicate epiderm; and the probability is increased when it is noticed that the phenomenon is most decided in young individuals. It may be possible, however, that the Ophiuran has no photogenic structures, and that the light is the product of foreign animal substances which have become entangled by it as it moved over the mud of the sea floor on which it feeds.

Many years since, Quatrefages, in a very exhaustive memoir on the phosphorescence of marine animals,* attributed the light of the Ophiuran he examined to muscular contraction, and he found it arising between the plates of the arms. He did not see any luminous condition of the disk. But that this occurs is undoubted, and there are no muscular fibers there.

A considerable number of Crustacea are luminous under certain conditions, and the light emission is sufficiently remarkable. In very transparent ten-footed kinds, and indeed in the small Entomostraca, as well as in many of the Sand hopper group, a vivid short-lived light is emitted. Its color is often redder than that of any other animals, and it is localized at first, for it starts from the junction of the legs with the body, and extends rapidly beneath the skin; and then it becomes diffused, the whole body glowing for a while. Some of the host of marine worms are luminous occasionally; and especially some of the genus *Nereis* and of the tube-making *Chætopterus*.

They emit a greenish light, and Quatrefages noticed that the phenomenon consists of a quick series of scintillations, which pass along several segments of the body, lasting but an instant. The flashes can be produced by irritating the worm, and they appear to accompany muscular contraction. Finally, as regards marine animal luminosity, the Cuttles and Squids are slightly light emitting on their outer surface.

I am not aware of any fresh water invertebrate which possesses the gift, and the statement that Infusoria are occasionally luminous does not appear to be founded on satisfactory evidence.

On land, certain Myriopoda give out a sparkling light, resulting from muscular contraction; and there is a remarkable slug found in Teneriffe, *Limax* or *Phosphorax noctilucus*, which has a luminous pore in the posterior border of the mantle. Many insects have tiny little spots on them which emit light, and it would appear that the localization of the minute phenomenon is in relation with wax glands. On the other hand, the great headed Fulgora, or lantern fly, is said by some naturalists to glow with red and white all about the forepart, and by other observers to do nothing of the kind.

The great display is produced by some species of two families of beetles, the *Lampyridæ* and *Elateridæ*, and the glowworm is one of the former. Belonging to the genus *Lampyris*, it is in classification, in the neighborhood of the family *Telephoridæ*, and its close ally is the genus *Drilus*, in which great disparity between the sexes is not accompanied by luminous phenomena. *Lampyris* and *Drilus* lead the same kind of lives, and in the larval state are carnivorous, preying on snails, whose body they devour during life. As every work on entomology has descriptions of species of *Lampyris*, it is only necessary to group the gifts of all, in the following remarks. The large yellow egg is even luminous on first leaving the body of the female. It is stuck on to moss, low grass, or even earth, by a viscid fluid; and when it is hatched the long narrow flat larva soon begins its cruel life, and has an apparatus for brushing off the slime of its victim. It attains its full size in warm Aprils, and some turn to the pupa condition in the summer; but usually the larva lives on, hibernates in the winter, and turns to the pupa in the spring. The larva has photogenic organs on the antepenultimate segment of the body (Pl. Fig. 9); they are on its under surface, one on each side of the middle line, and are like small sacs in shape. Overlapped more or less by the segment in front, they become visible when the insect extends its abdomen, and then they are noticed to be luminous. On the other hand, when the body is retracted they are hidden and the light is not seen. Under all circumstances the light is excessively feeble.

When about to undergo the first metamorphosis, this larva becomes quiescent, and after skin shedding, a pupa is presented—not a quiet one, however, for it has the power of moving the antennæ, head, and legs, and of twisting its body about and pushing itself along by the alternate contraction and expansion of the abdomen The female pupa is without wings, but the male has them, and the elytra, in a rudimentary condition. Both are slightly luminous. The last metamorphosis develops the perfect males and females, the last being apterous, the former being able to fly. Both, and not only the females, as has been popularly believed, are light emitting, but the lady has greatly the advantage in brilliancy, and in the extent of her photogenic apparatus In her (Fig. 7), they consist of six separate thin sacs of a white color, each one occupying most of the width of the underside of a segment of the body. They are situate immediately beneath the skin of the ventral surface of the three segments which precede the last but one; and in the male they are on the penultimate and antepenultimate segments only (Fig. 8). In the female the sacs on the fourth and fifth segments from the end are rectangular and large, and the others are smaller. A thin expanse of the common soft integument covers them, and they are in contact with the last two nervous ganglia, many large air tubes, and, in the female, with the sexual organs. They are exposed and hidden by the expansion and contraction of the abdomen, and their light is visible under the first condition; but when in full vigor, the luminous appearance may diminish, but not be quite lost under the second. This has something to do with the glowing. In all the grades of development the sacs are more worthy of the name of layers or laminæ, and they consist of a mass of large cells with nuclei and refractive granules. These are aggregated without order, in the larva, and covered with an investing tissue, in which tracheæ (air-tubes) and minute nerves ramify, the tracheæ entering within and coming in contact with the cells joining on to their walls (Fig. 10). In the female, the lamina is made up of a number of these cell aggregates or organs, and there is a yellowish tinge in the part nearest the outer skin, and the back part is crowded with the refractive granules, and has a white and opaque tint. It is said, and one would like it more satisfactorily proved, that the refractive granules contain uric acid; and, on the other hand, it is by no means certain that the whole is not closely allied to that very recondite and unstable organic compound, wax.

Many entomologists are disposed to connect these highly fatty, light-emitting organs, so well provided with air-tubes and nerves, and so close to those organs where the most rapid structural changes progress in some periods of insect life, with the great mass of body and inter-muscle fat. This fat, however, diminishes with the advance of the sexual organs, and we know that in some insects a positive development of immature young takes place in it; but the luminous organ is present in the larva, and is most developed in the perfect state. Hence more knowledge is required before these views can receive universal acknowledgment.

The sacs continue to shine, for a while, after removal from the body, and the epithelium looking cells retain their luminosity, when smeared over a moist surface for a time, but drying destroys the power. Oil and water do not affect the sacs; acids and alkalies arrest the light, and glycerine also, but the light returns on washing it off. The glow becomes extinct *in vacuo*, but returns on the admission of air.

Mr. Darwin writes, "All the fire-flies which I caught here (at Rio) belonged to the Lampyridæ (in which family the English glowworm is included), and the greater number of specimens were of *Lampyris occidentalis*. I found that this insect emitted the most brilliant flashes when irritated; in the intervals the abdominal rings were obscured. The flash was almost co-instantaneous in the two rings, but it was just perceptible first in the anterior one. The shining matter was fluid and very adhesive; little spots, where the skin has been torn, continued bright with a slight scintillation, whilst the uninjured parts were obscured. When the insect was decapitated the rings remained uninterruptedly bright, but not so brilliant as before. Local irritation with a needle always increased the vividness of the light. The rings in one instance retained their luminous property nearly twenty-four hours after the death of the insect. From these facts it would appear probable that the animal has only the power of concealing or extinguishing the light for short intervals, and that at other times the display is involuntary. On the muddy and wet gravel walks I found the larvæ of this *Lampyris* in great numbers. They resembled in general form the female of the English glowworm. These larvæ possessed but feeble luminous powers; and on the slightest touch they feigned death, and ceased to shine, nor did irritation excite any fresh display."

The Elater tribe furnish the commonest "fire-flies" of the tropics, and the light comes from a spot on either side of the front part of the body, where there is a yellow oval mass of cell aggregates and tracheæ.

There is great scope for thought and speculation about all these facts, and it is evident that we do not yet know enough of the anatomy and physiology of the photogenic organs of many animals. But with our present knowledge it is possible to obtain some tolerably definite ideas on the subject of animal luminousness. First, the spectroscope gives no satisfactory assistance. It tells us that the light is not produced by a gas, and still that there is something unusual about it, for the green part of the spectrum, in which it is found, glows, as it were, in the least refrangible part, or may be said to be more intense near the red than in the other part of the green. That the term phosphorescence is of no scientific value is evident; it only relates to the similarity of the glow of the *Lampyris*, and the light accompanying the oxidation of phosphorus, and there is not enough (if there be any) of the element in these tiny things to account for the special phenomena.

Fungi, decaying fish and the flesh of lobsters are luminous under certain conditions, but the phenomena differ from those of the living animal, and are no more to be satisfactorily compared, than they are with the sharp emanation of light on the crystallization of tartar emetic, or with the results of the mixture of hydrochloric acid and arsenic during its crystallization.

It is evident that in some animals there is no special photogenic structure; that in others it is present as highly refractive cell contents; and in the Insecta there are aggregations of these cells into special organs, which are supplied with air-tubes, nerves, and blood. It is equally clear that whilst in the first and second groups, artificial irritation and the natural stimulus of the movement of the sea-water increase the light, and even induce it, there is still the power of intrinsic self-illumination. Quatrefages points out the extreme sharpness and brightness of the localized spots of light on *Noctiluca*, and insists that in a corresponding mass of them there is as much light given out as from the organ of *Lampyris*. There is, however, this difference between the light. It is extinguished in both *in vacuo*, but it returns only in the *Lampyris*. Two sets of phenomena are probably present, and in the simplest animal the physical cause of the light is probably different from that in the beetle. Certain it is, that all the agents which produce contraction of the protoplasm of *Noctiluca* determine the light, and if a persistent contraction is set up, the light is equally persistent, and death results. As the light comes from spots about the region where growth, the deposition of fresh protoplasm and its differentiation into minute granules are in full operation, and as moderately careful experiment has proved that there is no increase of temperature accompanying the light, the cause of it cannot be referred to "combustion," to oxidation, or to phosphorus; but to local and then general molecular movement of intense rapidity, which can produce light waves. In the instance of the *Pholas* large quantities of this luminous substance can be collected, but the temperature bears no relation to the light. If twenty or thirty female glowworms are put on the hand, which is rendered as visible as by the light of a candle, there is no appreciable temperature above that of the cold, clammy insect. The notion of oxidation of matter producing brilliant light without a measurable amount of heat is of no great value; and certainly if a female *Lampyris* glowing on damp grass so as to be luminous entirely underneath, and to have her light visible for many paces off, could evolve a corresponding or relational amount of heat, she would be fried. During the daytime, if *Lampyris* be watched, whilst under the shade, she is not luminous as at night, and it is difficult by irritation to get her to shine. Again, there is manifest paling of the light after midnight, and the neighborhood of the male causes both to flash out more. The influence of the nerve is the most manifest in the Insecta, less so when the structure is rudimentary in the Alcyonaria, and it is absent in *Noctiluca*. But still, as the simplest nerve is protoplasm differentiated slightly and formed into masses and long lines; so even in *Noctiluca*, the light, situated as it is, at the very extremity of the thready protoplasm, which is ever streaming at its surface with granular matter, may be said to be in relation with localized potential, the energy of life. The phenomena of the so-called phosphori, or the luminosity of such substances as sulphide of barium, even when the emission of light is brief, is a consequence of molecular change and movement. Certain minerals obtain this movement after exposure to the sun, or to artificial but intense light, and in its production the energy of the light given has been transferred, and, as usual, more or less degraded. One can understand that if there is an energy of life, linked on to the unstable albuminoid, the basis of animal and vegetable organisms, and it can produce heat and electricity, it can, as the highest physical potential, produce molecular movement sufficient to develop light waves.—*Popular Science Review.*

* See the literature of the subject at the end of my article, "Photogenic Structures"—"Micrographic Dictionary," third edition.

DEMONSTRATION OF THE ROTATION OF THE EARTH BY THE GYROSCOPE.*

J. M. ARNOLD.

PROF. BOHNENBERGER, of Tubingen, in 1817, invented an instrument for illustrating the laws of rotary motion and the precession of the equinoxes. It consisted of a rotating disk placed inside of three rings, similar to the gimbals of a ship's compass, and so adjusted that all its movements were about its center of gravity. This was called a gyroscope. Atkinson and Elliott, in England, and somewhat earlier, in 1831, Prof. W. R. Johnson, of Philadelphia, constructed modifications of this instrument, but it is believed that the latter first devised that peculiar form by which a heavy metallic disk seems to lose its weight, and to remain suspended, with its axis supported at one end only.

In 1853, Foucault constructed an instrument similar to the gyroscope of Bohnenberger, by which the rotation of the earth was rendered visible. Foucault's instrument was constructed with great delicacy, and a rapid motion was communicated to the disk by means of machinery that could be instantly disconnected. The plane of the disk being then brought into the plane of the meridian, and a telescope directed to a graduated arc on the surrounding frame, a movement was observed, caused by the tendency of the axis of the rapidly revolving disk to remain nearly constant in direction, while the rest of the machine partook of the earth's rotation, and moved around it.

I wish to present to your notice an instrument that I have recently constructed, it being a modification of the common gyroscope, more simple than that of Foucault, and working on a different principle.

Inside of a brass ring, two and one-half inches in diameter, there is pivoted an ordinary gyroscope wheel, weighing, with the ring, 93 dwts. Near one end of the axis a center is made, which being placed on the sharp point of a gyroscope stand, the usual phenomena of the gyroscope may be exhibited.

To demonstrate the rotation of the earth, a steel rod, about five inches in length, is screwed into the ring so as to form a continuation of the axis of the disk, and having a counterpoise weight at its end, movable by a screw cut on the rod. Another smaller weight on a wire, perpendicular to

* Read before the Boston Scientific Society, June 15, 1879.

the rod, is used for adjusting the height of the center of gravity. The point of the standard is now replaced by a standard carrying two upright pieces surmounted by polished agates, such as are used in compass cards. These stones are about an inch and one-half apart, and support the gyroscope with its counterpoise by means of hardened steel points attached to the ring near one end of the axis of the wheel, and so placed that the line joining them will be perpendicular to the axis.

The instrument is now placed with the axis of the wheel in the plane of the meridian, and the center of gravity of the system is so adjusted that the axis will be elevated about 45°, and the center of gravity be slightly below the line joining the supporting points. The whole will now be somewhat like the balance beam of a pair of scales, but instead of being in equilibrium in the horizontal position, as in the scales, it will come to rest at an angle of 45°. The end of the counterpoise rod is sharpened to a point, and indicates on a graduated arc the position of the axis of the disk. If now a rapid motion be communicated to the wheel, by means of a string wound upon its axis, and the instrument placed as before described, the wheel will have two motions, one a rotation on its own axis, the other a rotation about an axis perpendicular to this, which will be imparted by the rotation of the earth.

The effect of these two rotations, which can be easily demonstrated, will be to cause a slight deflection about a third axis perpendicular to each of the others. This third axis will, in this case, be the axis of support, or a line joining the points resting in the jewels. This will evidently change the position of the index on the graduated arc in a direction depending on the direction of rotation of the revolving disk.

But the angular motion caused by the rotation of the earth is so slow, that it might be thought this would not be sufficient to overcome the friction on the supporting points; that it is sufficient, can be shown by the following experiment:

The deflecting force of the revolving disk, when used as an ordinary gyroscope, is such that it will support its own weight when making an orbital revolution of 12 times per minute. This is found to be equal to a force of 1,042 grains acting at the end of a lever arm of 3 inches. Now the velocity of the wheel being constant, the deflecting force is directly proportional to the velocity around the second axis. Hence, knowing by experiment the deflecting force, with an orbital motion of 12 times per minute, or 17,232 times in a sidereal day, the deflection for a velocity of one revolution to each sidereal day will be represented by the fraction

DEMONSTRATION OF THE ROTATION OF THE EARTH BY THE GYROSCOPE.

$\frac{1042}{17232}$, or a little more than one-seventeenth of a grain placed at a horizontal distance of 3 inches from the fulcrum. As the instrument will move with much less than this, it is evident that it must show a deflection of the index, caused by the rotation of the earth.

I will now give the results of a series of experiments.

Having adjusted the center of gravity as described, and with the axis of the disk directed toward the celestial equator, a rapid motion was given the disk by a string wound on the upper side of the axis; it was then placed on the supporting jewels, where it oscillated to and fro for a few times. When the oscillation had become quite small, the reading of the index was recorded in the following table, in the left hand column:

West to East.	East to West.
48·75	48·00
48·75	47·50
48·50	48·00
48·75	47·50
48·75	47·75
49·00	48·00
49·25	48·00
49·00	48·00
8)390·75	8)382·75
48·84	47·84

The wheel was then stopped, and the string wound on the lower part of the axis, so that the rotation would be in the reverse direction; the reading of the index was then noted and placed in the right hand column of the table. The experiment was repeated, reversing the motion of the wheel each time, until the record shows eight trials for each direction. The mean of each column being taken, we find a difference of one degree, showing that when the disk is rotating so that its top passes from west to east, the counterpoise was raised from its position of equilibrium, when at rest, one-half of a degree, and when the disk was rotating in the opposite direction, the counterpoise was depressed by the same amount.

The whole apparatus was then turned half way around, and the series of experiments repeated, reversing the motion each time as before. In this position the axis of the disk was parallel, or nearly so, to the axis of the earth, consequently no deflection should be caused by the earth's rotation, and the machine should behave as if the earth was at rest. The result of the trials in this condition are given in the following table:

West to East.	East to West.
49·25	49·00
49·25	49·25
49·25	49·50
49·00	49·25
49·25	49·50
49·50	49·25
49·50	49·50
49·50	49·50
8)394·50	8)394·75
49·31	49·34

The means of these columns, it will be seen, agree within a small fraction of a degree.

In order to ascertain the amount of force represented by the deflection shown in the previous experiments, light substances of known weight were placed on the counterpoise when the machine was at rest; in this manner it was found that one-sixteenth of a grain acting at a horizontal distance of three inches from the fulcrum, would produce a deflection of one-half a degree. This, it will be perceived, agrees very nearly to the estimated deflecting force already mentioned.

Thus, with this simple little instrument, it can be demonstrated not only that the earth has a motion of rotation, but the direction of that motion, and an approximate value to its velocity can be obtained.

In the foregoing experiments, the instrument was so adjusted that the center of gravity was slightly below the fulcrum; by adjusting the center of gravity still closer to the fulcrum, a more marked deflection can be obtained, varying from two to three degrees in each direction; but the oscillations about the fulcrum will be slower, and the index longer, in coming to rest.

The instrument as described is adapted for experiments at or near 45 degrees of latitude. At the equator a different arrangement would be necessary, in order that the wheel could be supported on a horizontal axis bearing east and west, but with its own axis pointing to the zenith.

For the illustration of the laws of rotary motion, the gyroscope has no superior; and if by a simple attachment, which the amateur mechanic can easily make for himself, a movement is obtained depending upon the rotation of the earth, additional interest will be lent to this beautiful scientific toy.—*Science Observer.*

THE BRIGHT LINES OF COMETS.

Prof. G. J. Stoney read a paper before the British Association "On the Cause of Bright Lines of Comets." He remarked that Dr. Huggins and other observers had seen the bright lines of the carbon spectrum in the spectra of several comets. This established the fact that some compound of carbon was present in comets. In what had been hitherto written on this subject it had always been assumed that the compound of carbon was incandescent, and on that account emitted these bright lines. Mr. Stoney suggested, however, an alternative hypothesis which he believed to be entitled to much weight. It was in effect that these lines were due to the sun's light falling upon the compound of carbon and rendering it visible, in the same way that light renders the moon, the planets, and other opaque objects visible, the vapor of carbon being opaque in reference to the particular rays, which appear as bright lines in its spectrum. An opaque body was visible in the presence of a luminary from three causes, because of such a scattering of the incident light as takes place when a transparent body is reduced to powder, owing to the reflection of light from its surface, and also to phosphorescence.

He remarked that phosphorescence consisted in the exaltation of such molecular motions by radiant heat as were unable readily to communicate their superfluous energy to the other kinds of motion among the molecules. About two years since he examined the spectra of some colored vapors when strongly illuminated by condensed sunlight, and at length found in the vapor of iodine a gas which afforded a spectrum of bright lines seen in that manner. This observation has recently been confirmed by Mr. Charles E. Burton, who was at present making arrangements for a more perfect examination of this new spectrum.

EVAPORATED FRUITS.

The time has passed when it is profitable for the producer to depend on the sun or on ovens, or even heated rooms, to preserve perishable fruits. The markets everywhere show this. During the past winter sun-dried apples have sold at three or four cents, while evaporated apples have sold at from eleven to twelve cents at wholesale.

Sun-dried peaches have sold at from seven to eight cents, while evaporated peaches have sold, and the market has been emptied, at from thirty to forty-five cents at wholesale; while even unpared peaches evaporated have all been disposed of at from twelve to fifteen cents. The producer must accept the position and adapt himself to it or go under. It is vain for him to contend with the markets in this direction.

The eye and the taste give evidence sufficient of the vastly superior quality of evaporated over sun or kiln-dried fruits. Nor should the statement be received that even the best evaporated fruit is in no wise distinguishable from green fruit; unless the word cooked be inserted before the word green. Then, when made into pies, it is difficult in the winter season or in the spring to discover a difference between "green apple pies" and pies made from the best evaporated apples or peaches, either in the color or by the taste. It is not long since we were eating apple pie where we knew they had a supply of winter apples, and supposed we were eating green apple pie, when we were informed that it was made from evaporated apples. We do not believe one in a dozen could, under the circumstances, have told the difference. The same fruit used as a sauce, simply soaked over night and then slightly sugared, very closely resembles green apple sauce. So of peaches and some other fruits. Evaporation, while by the great heat necessary to give freshness to the color and perfection to the process, does modify the taste of the fruit, though less than by any other process of preserving.

It is a philosophical process, carrying out the ripening operations of nature more rapidly by artificial means. Hence there is, while the natural juices of the fruit are removed in the midst of an atmosphere saturated with moisture, an increase of actual grape sugar, not cane sugar, from fifteen to twenty-five per cent.; so that evaporated fruit requires that much less of sugar when used. But it is not all evaporated fruit that is perfect. Ignorant or careless hands make poor fruit. Yet the poorest evaporated is superior to the best sun-dried where the color is no better.

Varieties of apples or peaches give variety to the color. Some varieties scarcely change in color at all. Over-ripe fruit is darker colored than that which is less ripe. The proper point of excellence for the evaporator for peaches, is about forty-eight hours before they are fit to be cut up for table use. Five or six hours in the evaporator will perfect the fruit as much and increase the quality far more than forty-eight hours on a railway train or on the tree.

Three things are essential in an evaporator: 1. The fruit chamber should be at a high temperature, from 212 degrees to 240 degrees, when the fruit first enters. 2. The air in which the fruit is evaporated should be saturated with moisture. 3. A strong current of cold air should enter at the bottom of the evaporator and be carried off above the fruit without stagnating. The more rapidly a current of moist heated air can be made to pass through the fruit, the more perfect the product. Any evaporator which does not secure these results is not a perfect machine. But skill and good judgment to know how long fruit should be exposed to such influences, and care in not allowing the surface to become discolored before it is put into the evaporator, are absolutely essential to the production of the best quality of evaporated fruit. An oven is not an evaporator; it is simply a kiln. In kiln-drying or sun-drying the surface dries first. In evaporating the natural moisture is expelled from the fruit in a moist, hot air chamber, which keeps the surface always moist.

Fruit after coming from the evaporator with only twelve per cent. water in it, should be put up in a dark closet secure against insects, or better, put up in moth-proof packages, when it may be kept in a cool place almost indefinitely without injury.—*Ohio Farmer.*

YEARLY RENEWAL OF STRAWBERRY BEDS.

By President J. M. Smith.

You refer to some remarks of mine with regard to the yearly renewal of strawberry beds. With your consent I will give the many thousands of readers of the *Tribune* the plan which seems to me to be the best after many years of experience. I have repeatedly tried both fall and spring setting, but much prefer the latter. With the former I have sometimes been very successful, but with the latter have never had a failure. I select a piece of sandy loam that is in a high state of cultivation, preferring it should be rather moist than too dry; still no water must ever stand upon the ground or about the roots of the plants, if you are to have a large crop. Plough deep, and manure heavily. Have the land in first-rate condition in every way. When the plants are just starting in the spring, we take them up and reset in the new beds. We take strong, healthy plants, being more careful with regard to the roots than the tops. The ground is marked off in rows two feet apart each way, and the plants set where the lines cross. This, of course, makes them in rows each way, and two feet apart each way, which renders the cultivation very easy.

"But," said a friend who was visiting me not long since, "I should not think that you, with your system of high cultivation, could afford to give two years to one crop of strawberries, even though it might be a large one." I do not think so either; and in order to make the land pay its way the first season, we have some large early cabbage plants, and generally set them in every second space. For this purpose the Jersey Wakefield is preferred. Being set in every second space, they are of course four feet between the rows, and may be only sixteen to eighteen inches apart in the rows. The ground being very rich, they are brought forward very fast. They grow nicely together until the latter part of July or first part of August, when the strawberry plants are throwing out runners very rapidly. But by this time the cabbage is headed and cut. The roots are pulled out, the ground put in the best of order, the runners trained in every direction about the plant. The cabbage has paid nicely for the season's work upon the strawberries, and we can now afford to help them do their best until late in the fall. No weeds are allowed to grow, and by the time winter sets in they are a sheet of the most beautiful dark, deep green that can be imagined.

Just as the ground freezes up for the winter they are mulched about one inch deep. I do not like straw for covering, because there are always more or less foul seeds in it that come up in the beds early in the spring, and sometimes annoy us very much. I prefer either marsh hay or pine leaves. The next spring the covering is taken off, and another coat of well-rotted manure put on the top of the ground. We often use ashes for the spring dressing, and like it very much. We put on about 75 to 100 bushels of unleached ashes per acre; if leached, considerably more than that. The plants now come forward with great rapidity, and by the middle of May are about as beautiful a sight as a strawberry-grower can desire to see. From this time on they are watched with great care. All weeds and grass are carefully taken out. If they are more than usually full of blossoms, another coat of fine manure is put on to prevent the plants from becoming too much exhausted before the last of the fruit is picked. If the weather is too dry for them, they are watered artificially. In short, nothing is left undone that we know how to do to secure an immense yield, and we rarely fail.

In the summer of 1875, by this system, we picked from an exact quarter of an acre 3,571 quarts of merchantable berries. This was at the rate of 446½ bushels per acre. I cultivate chiefly the Wilson, and find that when they have borne one of these very large crops the plants are so completely exhausted that we can never get anything more than a very moderate crop of indifferent fruit afterward; consequently we turn it over immediately after the last berries are picked, and again set it with cabbage; and in this manner we get three good crops in the two years instead of one. One need not of necessity set with cabbage either the first or second time; there are various other plants, such as bush-beans, lettuce, onions, etc., that will do equally well for the first season, and rutabagas or flat turnips for the after-crop. But the great principle with this, as with other branches of agriculture, is to have our land in such condition that plants must grow and cannot help it; and then keep them constantly going forward, and never, if possible to prevent it, allow them to stand still during the growing season.—*N. Y. Tribune.*

Dr. Barnes, of San Diego, Cal., ascribes the singular mound formations covering the dry soil of that region to the effect of wind and certain low-lying, broad-branched plants with a large system of roots, chief among which is the *Rhus laurina.*